

UTILITY PATENT APPLICATION TRANSMITTAL

Under Small Entity Status

(New Nonprovisional Applications Under 37 CFR § 1.53(b))

Attorney Docket No.

5297/132

TO THE ASSISTANT COMMISSIONER FOR PATENTS:

Transmitted herewith is the patent application of inventors Brian H. Silver and Larry D. Annis, entitled Diaphragm Pump and Pump for Double-Breast Pumping, for a:

- ( ) Original Patent Application.
- (x) Continuing Application (prior application not abandoned):
- ( ) Continuation (x) Divisional ( ) Continuation-in-part (CIP) ( ) Regular Filing of Provisional of prior application No. 09/055,101 filed on April 3, 1998, which is a continuation-in-part to U.S. Patent Application Serial No. 08/510,714, filed August 3, 1995.
- (x) A statement claiming priority under 35 USC § 120 is attached.

Enclosed are:

- (x) Specification; 36 Total Pages (including title page) (x) Drawing(s); 16 Total Sheets.
- (x) Oath or Declaration:
- ( ) A Newly Executed Combined Declaration and Power of Attorney:
- ( ) Signed. ( ) Unsigned. ( ) Partially Signed.
- (x) A Copy from a Prior Application for Continuation/Divisional (37 CFR § 1.63(d)).
- (x) Incorporation by Reference. The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered as being part of the disclosure of the accompanying application and is hereby incorporated herein by reference.
- ( ) Signed Statement Deleting Inventor(s) Named in the Prior Application. (37 CFR § 163(d)(2)).
- (x) Power of Attorney. (x) Return Receipt Postcard.
- ( ) Associate Power of Attorney. (x) A Check in the amount of \$462 for the Filing Fee.
- ( ) Preliminary Amendment. ( ) Information Disclosure Statement and Form PTO-1449.
- ( ) A Certified Copy of Priority Documents (if foreign priority is claimed).
- ( ) Statement(s) of Status as a Small Entity.
- (x) Statement(s) of Status as a Small Entity Filed in Prior Application, Status Still Proper and Desired.
- (x) Other: Please cancel Claims 1-7, 10-17, 25, and 32-39 prior to calculating the filing fee.

CLAIMS AS FILED

FOR	NO. FILED	NO. EXTRA	RATE	FEE
Total Claims	15 - 20	0	\$9.00	\$ 0.00
Independent Claims	6 - 3	3	\$39.00	\$ 117.00
Multiple Dependent Claims (if applicable)				\$ 0.00
Basic Filing Fee				\$ 345.00
Total Filing Fee				\$ 462.00

- (x) The Assistant Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 50-0930. A duplicate copy of this sheet is enclosed.
- (x) Any additional filing fees required under 37 CFR § 1.16.
- ( ) Any patent application processing fees under 37 CFR § 1.17.

Respectfully submitted,

By:

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Applicant or Patentee:

Brian H. Silver and Larry D. Annis

Serial or Patent No:

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Case No.: 5297779

For:

Diaphragm Pump and Pump for Double-Breast Pumping

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS  
(37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN**

I hereby declare that I am

- ☐ the owner of the small business concern identified below:
- ☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN

Medela, Inc.

ADDRESS OF CONCERN

4610 Prime Parkway, McHenry, Illinois U.S.A.

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled Diaphragm Pump and Pump for Double-Breast Pumping by inventors Brian H. Silver described in

- ☒ the specification filed herewith.
- ☐ application serial no. \_\_\_\_\_, filed \_\_\_\_\_.
- ☐ patent no. \_\_\_\_\_, issued \_\_\_\_\_.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below\* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e). \*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME

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☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

NAME

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☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

SIGNATURE

NAME OF PERSON SIGNING

TITLE OF PERSON OTHER THAN OWNER

ADDRESS OF PERSON SIGNING

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Case No. 5297/79

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE:

DIAPHRAGM PUMP AND PUMP FOR  
DOUBLE-BREAST PUMPING

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## DIAPHRAGM PUMP AND PUMP FOR DOUBLE-BREAST PUMPING

### RELATED PATENT APPLICATIONS

This patent application is a continuation-in-part of U.S. Serial No. 08/510,714 filed August 3, 1995.

### BACKGROUND OF THE INVENTION

The invention relates to motorized pumps, and more particularly, to breastpumps.

Breastpumps are convenient for nursing mothers, because, among other things, they allow the nursing mother to draw off breast milk to feed to the child at a later time when the mother may not be present. For some mothers, breastpumps are required, particularly when the child has suckling difficulties, or if the mother has problems with excessive or deficient milk production, or cannot empty completely. Some mothers also require breastpumps in the event of soreness or injury of the mamilla, or sunken mamilla.

Manually-driven breastpumps are commonplace. However, they typically require the use of both hands to pump a single breast--one to hold the breast shield/pump in place, and the other to drive the pump. There are also manually driven breastpumps that can be operated with one hand, as by using a lever-type drive mechanism. They also obviously require some manual effort to operate.

Motor-driven pumps for breastpumps, such as battery-powered or house-current powered, also have been marketed. While eliminating the need for manually reciprocating the pumping mechanism, those pumps made for operating two breast shield assemblies at once--double-pumping--have typically been quite large, and often quite heavy. Smaller battery-powered pumps which are part of the breast shield assembly itself have not historically been adapted to, or capable of, double-pumping off the same pump.

## SUMMARY OF THE INVENTION

The present invention was designed with many of the foregoing considerations in mind. It has a principal objective to provide a relatively inexpensive but efficient pump that is readily portable because it is compact and lightweight.

5       The motor drive mechanism of the pump has a durable drive train, and the main vacuum-generating pump components--flexible diaphragm and rigid cap--are each preferably detachably mounted together within a frame. Assembly, and disassembly--as for repair or cleaning--are therefore efficiently and easily accomplished. A pressure regulator valve mechanism on the rigid cap further  
10       provides simple manual control for varying negative pressure developed by the pump.

      These features make the inventive pump ideally suited for a breastpump. More particularly, the present invention in one form is an electrically-powered diaphragm pump mounted within a support frame contained in a soft carrying case. A zippered flap in the carrying case provides access to the front of the pump unit, which  
15       has spigots for attaching tubing that connects to breast shield assemblies.

      The diaphragm pump in one form of the invention has a durable drive chain comprising a drive shaft fit with an eccentric cam, to which is attached a follower. The follower is in turn pivotably connected to a puller that is attached to a flexible diaphragm. The diaphragm rests near or against the interior surface of a rigid cap, the  
20       latter being stationarily mounted. An expansible chamber is thus provided. In operation, the rotation of the drive shaft rotates the cam, causing the follower to move back and forth as it orbits the shaft. The puller moves with the follower, drawing the diaphragm away from the cap and forming a negative pressure that is communicated by one or two spigots to tubing attached to the breast shield assemblies.

25       It is also contemplated that the foregoing drive mechanism be adapted to drive two diaphragms in respective cap assemblies. In one such an embodiment, the puller would take the form of a yoke to which the diaphragms are connected. The follower would then reciprocate to move the puller and associated diaphragms toward and away from the caps. In another such embodiment, a pair of opposed pullers would be  
30       used in a push-pull arrangement, whereby the two pumps cycle oppositely. Of course,

this diaphragm and cap assembly is but one type of expansible chamber pump that could be advantageously used with other aspects of the invention.

5 The pump further can include a vacuum regulator device on the cap. The regulator device can also be located elsewhere, such as anywhere between the breast shield and the vacuum source, or on the breast shield itself. In one embodiment, the vacuum regulator comprises a rotary valve member mounted for rotational movement on the rigid cap. An aperture is formed through the valve member. At least one hole or recess is formed through the cap member, and communicates with the pressure region generated between the cap interior and the diaphragm.

10 The valve member has a first position wherein the valve aperture and the cap hole are aligned to place the pressure region in communication with atmosphere, and a covered position wherein the valve aperture and the cap hole are unaligned, with the valve member thereby closing the cap hole. A maximum and minimum vacuum level are thereby provided, depending on whether air can be drawn within the cap or not, as  
15 controlled by the valve.

A second hole different in size from the first cap hole can be additionally provided, establishing a second position wherein the valve aperture and the second cap hole are aligned for a different vacuum level. Maximum, medium and minimum vacuum levels can thus be made available through adjustment of the cap hole sizes.

20 The foregoing vacuum regulator device has further been modified in another embodiment. In the latter form, the rotary valve member has a crescent-shaped channel formed in its base (the part that is in contact with the cap). The aperture through the valve member extends into this channel. Two cap holes are formed in the cap. In the minimum vacuum position, the channel overlies both cap holes; in the  
25 medium position, only one hole, and in the maximum vacuum position, neither cap hole is in communication with the channel.

In yet another embodiment, the vacuum regulator device takes the form of a ring element which is rotatably mounted on each of a pair of caps in a pump adapted for double breast pumping. The rotatable element is easily manipulated. This also  
30 enables independent control of the vacuum being generated in each breast shield

assembly, for maximum convenience of the mother. The previously noted vacuum regulator devices above can likewise be used on each of the pump caps for the same advantageous independent control. Also, a continuously variable vacuum regulator device has been developed and can be used.

5 In a further evolution and adaptation of the foregoing invention utilizing a diaphragm pump, an apparatus has been developed which is particularly adapted for double breast pumping (although, and as will be seen, single breast pumping is also plainly included within its ambit).

10 In a first form of this adaptation, a double-diaphragm pumping mechanism has a pair of opposed pressure-generating units, in particular for generating a negative (vacuum) pressure. In a presently contemplated embodiment, one unit is adapted for direct attachment to a breast shield assembly. This unit has a diaphragm mechanism which is inserted into a receptacle, or collar, formed as part of the breast shield assembly. With the collar, the diaphragm forms a chamber within which a vacuum is  
15 generated. The other unit in this embodiment is self-contained, i.e., it has a diaphragm mechanism located within a rigid cover to form another (second) chamber within which a vacuum is generated. An outlet port is provided for communicating the vacuum this second chamber is generating. That outlet port is connected by tubing to another breast shield assembly.

20 A common drive mechanism serves to operate both of the pressure chambers of this double-diaphragm pump. In the foregoing embodiment, the drive mechanism uses an offset push-pull arrangement to create alternating negative pressure in the respective chambers. This results in alternating suction on the breasts. The double-diaphragm pumping mechanism of this embodiment (which is mounted to a breast shield assembly) is compact and light enough to be readily supported on a single  
25 hand-held breast shield assembly, such that it can be held in place by the mother on one breast with one hand, while the other breast shield assembly, which is being run off of the same pump, is held in place with the other hand.

30 In another form of this adaptation, the double-diaphragm pumping mechanism again has a pair of opposed pressure chambers, except they are built into a small

lightweight housing, such as might be set upon a table rather than held in the hand. This pumping mechanism utilizes a pair of opposed pressure chambers and a push-pull drive arrangement to alternately create a negative pressure in a respective chamber. An outlet is provided for each chamber which is connected via tubing to a  
5 respective breast shield assembly.

In a presently contemplated embodiment, the foregoing pumping mechanism further includes a speed regulator device for controlling the rate of pumping (i.e., the suction cycle or timing between negative pressure events). The "table-top" version also has a sound-deadening construction molded into the housing.

10 Other features and advantages of the present invention will become apparent from the detailed description that follows taken in conjunction with the drawings, described below.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a perspective view of a first embodiment of a diaphragm pump-driven breastpump made in accordance with the present invention;  
15

FIG. 2 is a cross-sectional view of the breastpump of FIG. 1 within a closed carrying case;

FIG. 3 is an exploded perspective view of most of the elements of the diaphragm pump;

20 FIG. 4 is a perspective view of a follower;

FIG. 5 is a cross-sectional view along line 5-5 of FIG. 4;

FIG. 6 is a perspective view of an alternative embodiment of a guide for the diaphragm pump;

FIG. 7 is a front view of the diaphragm pump cap of the first embodiment;

25 FIG. 7A is a modified form of a vacuum regulator;

FIG. 7B is a front view of another embodiment of a vacuum regulation device;

FIG. 7C is an enlarged view of the rim upon which a disk valve rotates in the embodiment of FIG. 7B;

FIG. 7D is a disk valve for use with the rim of FIG. 7C;



FIG. 7E is a side view partly in section of the embodiment of FIG. 7B;

FIG. 8 is an enlarged partial view in section of the diaphragm pump mounting arrangement shown in FIG. 2;

5 FIG. 9 is an enlarged partial view in section of an alternative form of the diaphragm;

FIG. 10 is a perspective view of a cap for use with the pump spigots.

FIG. 11 is another embodiment of the invention in the form of a pump for double breastpumping;

10 FIG. 12 is an enlarged sectional view of the breastpump of FIG. 11 having the pumping units attached thereto;

FIG. 13 is yet another embodiment of the invention taking the form of a tabletop version;

FIG. 14 is a sectional view taken along line 14-14 of FIG. 13;

FIG. 15 is a sectional view taken along line 15-15 of FIG. 13;

15 FIG. 16 is an enlarged view of the pump of FIG. 13, with the vacuum adjusting ring removed;

FIG. 17 is a perspective view of the interior of the half of the pump casing facing away from the viewer in FIG. 16;

FIG. 18 is a perspective view of the other half of the pump casing of FIG. 16;

20 FIG. 19 is a side view of another design for an embodiment of the invention;

FIG. 20 is a side view of yet another design for an embodiment of the invention; and

FIG. 21 is a perspective view of still another embodiment for a pump for double breast pumping.

25 **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

A diaphragm pump of the present invention is shown in embodiments as a vacuum (i.e., negative pressure) source for a breastpump. The diaphragm pump has uses in other environments and applications, however.

30 Referring to FIG. 1, a first embodiment of a diaphragm pump 10 according to the present invention is mounted within a rigid support frame 12. The support frame

12, which is somewhat boxlike, is carried and mounted within a soft carrying case or bag 14. It is shown connected to two breast shield assemblies 16 via tubing 18. Tubing 18 is attached at one end to respective spigots 20 (FIG. 2) via a slip-on fit over the spigots 20. With the tubing 18 removed from the spigots 20, the diaphragm pump 10 can be closed up within the case 14 via a zippered flap 22. Front plate 24 of the pump 10 may preferably be set back from the sidewall of the case 14 so that the zippered flap 22 is co-planar with the case front sidewall 14a when shut, although it need not be so inset. A wall 21 is formed surrounding the spigots 20 to protect the spigots from being accidentally broken off.

Case 14 has a number of interior compartments 26a, 26b, 26c, which constitute storage areas, such as for the breast shield assemblies 16, tubing 18, diapers, etc. Case 14 also could include a power source in the form of a battery (not shown) to which a commonly obtainable 12V DC gear motor 28 (FIG. 2) is electrically connected. An alternative power source could be an A.C. source (e.g., common 120 VAC service) through a DC converter, as at jack 27 (FIG. 1). The motor, power source and their various electrical connections are all conventional, and well known to those skilled in the art.

Case 14 has a flap-type closure 30, with a shoulder strap 32. Pump support frame 12 is fixed within a fabric compartment formed within the case 14. This may be by attachment of the front plate 24 to surrounding fabric 14b in a conventional manner, such as by riveting, stitching, adhering or some other common attachment. Here, front plate 24 frames the fabric 14b and captures it between the back of the plate 24 and the front 12a of the support frame 12. This is accomplished using toothed plastic rivets 34, or alternatively keyhole-type fasteners, which extend through the front plate 24, holes in the intervening fabric 14b, and then through holes provided in the front 12a of support frame 12.

The breast shield assemblies 16 are of the type sold by Medela, Inc. under the name MANUALELECTRIC, and generally shown in U.S. Patents Nos. 4,857,051 and 4,929,229, for example. The assemblies 16 have a breast shield 36 associated with a

milk bottle 38. A periodic vacuum generated by the pump 10 within the shield 16 serves to extract milk, which is then collected in the bottle 38.

Pump 10 has a guide 40 (FIG. 3) fixedly mounted to an inner frame wall 12b (FIG. 2), as by machine screws (not shown) with hole 41 provided to this end. An opening 42 is made in the guide 40 through which drive shaft 44 of the motor 28 extends. The diameter of the opening 42 is wider than the drive shaft 44 so that the latter freely rotates. Guide 40 has an elongated slot 45 formed therein which serves to confine and direct the movement of a guide pin 46 extending from a puller 48 connected to a follower 50 in a manner to be described hereafter.

FIG. 6 illustrates an alternative embodiment for the guide. Guide 40' functions in the same manner as guide 40. It is mounted to the inner frame wall 12b (FIG. 2) using machine screws through holes 41', and has an elongated slot 45' for the guide pin 46. Drive shaft 44 extends through hole 42'. Prime numbers used herein describe generally similar elements to their unprimed counterparts.

A cam or eccentric 52 is mounted on the drive shaft 44 (FIGS. 2 and 3). A collar-like portion 53 is formed off-center on the cam. The outboard end of the drive shaft 44 is received in a D-shaped opening 54 within the collar portion 53, with the drive shaft 44 keyed to the same shape in a snug fit. An e-clip or c-clip (not shown) can be attached to the end of the shaft to further secure the cam 52 on the shaft.

An aperture 56 is also formed off-center in the cam 52. When cam 52 is driven by the motor 28 turning the drive shaft 44, aperture 56 orbits around the drive shaft 44. Of course, and as will be evident from the further description below, the cam-and-drive shaft mechanism could be made to turn in less than 360° or reciprocate, and still achieve the desired movement.

Follower 50 (FIG. 3) is operably connected to the cam 52 via a hollow post 58 formed adjacent the rearward end of the follower 50. Post 58 has a diameter which is slightly smaller than that of the aperture 56 of the cam 52 within which it is received to freely rotate. For purposes of relative scale, the follower 50 shown herein has a longitudinal length of about 2.5 inches, and a lateral width of about .75 inch. A machine screw, washer and lock-nut combination 57 is additionally used for further,

but movable fixation (FIG. 2). An alternative embodiment of follower 50 is shown in FIGS. 4 and 5.

On the forward end of the follower 50 is mounted the puller 48 (FIG. 3). Puller 48 has two parallel legs 49 which extend from a puller cap 59 (FIG. 9) formed of an end disk or button 60 and a disk-like flange 61 spaced slightly inboard from the end disk 60. Puller 48 is connected to the follower 50 via a spring pivot pin 62 (FIG. 3) which extends through and is fixed within holes 63 in the legs 49 (only one of which holes 63 is shown in FIG. 3), and extends through hole 64 in the follower 50. The follower 50 is thus captured between the legs 49, but can pivot on the pivot pin 62. A guide pin 46, which is fixed within holes 65a, 65b in the legs 49, extends through a crescent-shaped aperture 66 formed in follower 50 (FIG. 3). When the follower 50 is mounted to the cam 52, guide pin 46 extends into the slot 45 of the guide 40 (FIG. 2).

A flexible diaphragm 70 is mounted on the end of the puller 48. Diaphragm 70 is preferably made of silicone, which could be rated for food contact but need not be, and has a general semi-spherical shape. End disk 60 (FIGS. 2 and 9) of the puller 48 is received within an orifice in the inboard side of the diaphragm 70, which orifice is formed by a thickened center part of the diaphragm 70 and a circular overlying flange part 72 (FIG. 2, and see detail of connection in FIG. 9). End disk 60 fits within this orifice in a button-like engagement. Flange disk 61 on the puller 48 presses against the flange part 72 of the diaphragm to further enhance the engagement. Alternatively, the diaphragm 70 could be molded integral with the end of the puller. It will be noted that a circumferential reduced wall thickness is formed in the diaphragm at 70a around the center area of the diaphragm 70 to facilitate flexion of the diaphragm. The wall thickness of the portion of the diaphragm 70 between the thickened center part and approximately the perimeter of the curved portion of the diaphragm is generally about .08 in.

An alternative form for the diaphragm wall is shown in FIG. 9. As shown in that figure, a corrugated or rippled interior provided by concentric channels 71 facilitate flexion of the diaphragm 70.

As shown in FIGS. 2 and 8, diaphragm 70 is mounted to the front plate 24 using a diaphragm mounting ring 74. Diaphragm 70 has a perimetrical shoulder 76 formed thereon from which depend inner and outer concentric circular flanges 78 and 80, respectively. With shoulder 76, flanges 78 and 80 form a circular channel. The outboard part of mounting ring 74 is received within this channel in a slip-on type fit of the diaphragm.

With the diaphragm 70 so mounted thereon, mounting ring 74 is received in an aperture formed in the front plate 24 and the frame front 12a. Two locking tabs 82a, 82b (FIGS. 2 and 8) extend outwardly at opposite sides of the mounting ring, and engage within cut-outs formed in the aperture of the frame front 12a to position the mounting ring by rotating the mounting ring into place.

A thin-width radial ring 84 (FIG. 8) is formed around the outside circumference of the mounting ring 74. This ring 84 underlies an outwardly extending lip 79 provided on the diaphragm 70, which lip 79 is pressed between the front plate 24 and the ring 84.

Overlying the diaphragm 70 (FIG. 8) is a rigid housing cap 86 (FIG. 2) made of polypropylene. Cap 86 has an inner surface roughly matching the curvature of the diaphragm 70, such that the diaphragm rests close to or against the interior surface of the cap 86. The cap 86 has a ring-like portion 89 extending outwardly from the edge of the semi-spherical dome portion of the cap 86. Concentric inner and outer cap flanges 88 and 90, respectively, depend from the ring-like portion 89 (see FIGS. 7 and 8 in particular). Inner cap flange 88 presses against the outboard side of outer diaphragm flange 80, with part of ring-like portion 89 overlying diaphragm shoulder 76. In conjunction with the mounting ring 74, this forms an air seal between the cap 86 and the underlying diaphragm 70. Additional concentric ribs 87a, 87b (FIGS. 8 and 9) are formed on top of the diaphragm shoulder 76 out of the same material as the diaphragm, and serve to facilitate this seal through compression against the cap shoulder 89. Outer flange 90 of the cap 86 is received in a snap-engagement with a cap mounting ring or collar 92 formed on the face of the front plate 24 to mount the cap 86 in place.

It will be recognized that the diaphragm 70 is one element that is moved relative to another member or base (the cap 86) to form an expansible chamber that has an expanding and contracting volume. Other such expansible chambers are considered to be adaptable to aspects of this invention, although the flexible diaphragm and cap arrangement has proved most advantageous at this time.

In operation of the pump 10, motor 28 is actuated, as by a standard on-off circuit utilizing switch 94 mounted in the front plate 24. Drive shaft 44 rotates cam 52 causing follower 50 to move rearwardly (relative to the front plate 24) and then forwardly. Puller 48 in turn moves rearwardly with the follower 50, drawing diaphragm 70 away from the inside of the cap 86. This generates a negative pressure (vacuum) in the space thus formed between diaphragm 70 and cap 86 (see dotted-line position of the drive chain elements and diaphragm in FIG. 2).

The rotation of the cam 52 with its movement of the pivotable follower 50 is designed to generally generate and follow the type of vacuum curve, and cycles per minute, shown and described in Medela U.S. Patent No. 5,007,899. Guide 40 serves to constrain the pivoting movement between the puller 48 and follower 50.

The negative pressure generated within the cap 86 is communicated through the outlet provided by the spigots 20 to one or both of the tubes 18 (depending on whether one or two breast shield assemblies 16 are being used). If only one breast shield assembly 16 is being used, it is contemplated that a cap 102 (FIG. 10) would be used to close the spigot 20 not being used. The cap 102 would further include a small vent hole 103 designed to nonetheless admit some air through the spigot and thereby into the cap interior in a manner to normalize the vacuum between single and double pumping usage, i.e., so that the vacuum drawn in a shield is about the same when only using one breast shield as when both breast shield assemblies are attached. Cap 102 has a loop end 104 to tether the cap 102 to one of the spigots 20.

A vacuum regulator is additionally provided for adjustment of the level of vacuum from the pump. This regulator takes the form of a flap-type valve disk 95 (FIG. 7) mounted in a circular-shaped depression formed in the center of hemispherical diaphragm cap 86. Valve disk 95 has a knob 96 (FIG. 2) which is

received in a lipped aperture 97 formed in the foregoing depression, in a pop-in fit. A knurled stem 98 extends from the valve disk 95 which is grasped to rotate the valve.

When valve disk 95 is rotated, a hole 100 through the disk 95 can be aligned with one or the other of holes 99a, 99b (FIG. 7) extending through the depression into the interior of the cap dome, or placed out of alignment with either hole 99a, 99b, the latter both then being covered and closed by the valve disk 95. Holes 99a and 99b are of different diameters, such that more air will pass through one than the other when aligned with disk hole 100. Accordingly, a preset "medium" (smaller diameter hole), "minimum" (larger diameter hole) or "maximum" (both holes covered) vacuum level range is provided. Crescent-shaped aperture 101 formed through the cap 86, which is under the disk valve 95, serves to vent air admitted into the cap interior (within the diaphragm/cap space created by the vacuum stroke) on the forward or compression stroke of the diaphragm 70 (diaphragm 70 moving toward the cap interior).

FIG. 7A shows a modified form of a vacuum regulator similar in concept to that of FIG. 7. In this form, hole 100 is formed through the disk 95, but extends into a crescent-shaped channel 105 formed in the underside of the valve disk, i.e., the part in facial engagement with the cap 86. As in the previous version, the disk 95 is located in a short well 106 defined by a collar (see FIG. 2). Disk 95 is rotated so that the channel 105 can be put in communication with one hole 99a, both hole 99a and 99b, or neither hole, for medium, minimum and maximum pressure, respectively. Also, a vent or leakage groove 107 is provided in the well beneath the disk 95 from a hole 99a and extending into and upwardly out of the collar 106. This provides a desirable amount of constant air leakage into the cap even at maximum negative pressure. This air leakage assures that there will be some air within the cap to apply a positive pressure on the return stroke, which can be used as a pneumatic assistant to move milk from a catch chamber into the container.

Yet another form of vacuum regulation device is shown in FIGS. 7B through 7E. In this embodiment, a rotatable regulator disk valve 200 fits upon a rim or collar 201 formed on the rigid cap 86''. A channel or recess 202 is formed on the outside of the rim 201. The channel is of constant width but of increasing depth (going from

on drawing  
Fig 7D  
Specified as 206

bottom to top as viewed in FIG. 7C). A port or hole 203 is in the deepest part of the tapered channel 202, and extends through the cap 86''.

Disk valve 200, which can be made of a somewhat flexible rubber material, has a nub 204 that fits within an appropriately sized aperture formed in the rim/cap, with a collar 204a that catches against a sidewall edge defining the aperture to rotatably mount the disk valve 200 in place. On the inside of the disk valve sidewall 200a is a recess 205 which communicates with atmosphere.

Thus, with the disk valve 200 turned so that its recess 205 is located over the shallowest part of the rim channel 202 and furthest from the hole 203, air "leakage" into the cap 86'' interior—through the disk valve recess 205 into the rim channel 202 and through the hole 203—is at a minimum. As the disk valve 200 is rotated so that its recess 205 is located at a deeper part of the channel 202, air flows more freely to the hole 203 and into the cap interior, toward a maximum when the recess 205 is over the deepest part of the channel 202 adjacent hole 203. A continuously variable vacuum regulating device is thereby provided.

A diaphragm pump is thus provided which is of relatively small size, with a durable drive chain. In the disclosed environment of a breast pump, it fits handily within a soft carrying case for quick and easy hook-up to one or more breast shield assemblies, which can be carried in the case.

It is envisioned that a thin disposable membrane-like cover (not shown) may additionally be provided over the diaphragm 70. This disposable cover would be between the diaphragm 70 and inside of the cap 86, and serve to further hygienically isolate the diaphragm 70 from any milk, air or the like which could be pulled within the cap 86 in the vacuum stroke. This disposable cover would be particularly useful if there were multiple users of the pump 10. Cap 86 would simply be removed and sterilized, and the disposable cover replaced between users. Alternatively, a separate cap 86, which itself might be disposable, for each user with a disposable cover could be provided.

Turning now to FIGS. 11 and 12, another embodiment of the invention takes the form of a double-diaphragm pump, i.e., a pump that has two diaphragms, which is



particularly adapted for double-pumping (although, as will be seen, it also has a single-pumping mode of operation). The double pump is generally shown at 110. It communicates vacuum (as will be described below) to breast shield assemblies 16' (again, prime numbers indicate generally similar elements to their unprimed counterparts). Breast shield assemblies 16' include a vacuum regulator 112 which  
5 modifies the amount of reduced pressure generated by the pumping action. The regulator 112 comprises a rotary member 113 with an internal groove or passage 115. The rotary member 113 has hollow ends. One hollow end encircles a ported structure 114 in the form of a nub having a pair of holes or ports (not shown). The rotary member  
10 113 fits within a cavity 116 formed in the breast shield assembly 16'. The ported nub 114 is at one end of the cavity, and a boss 117 is at the other end. The other hollow end of rotary member 113 is received on the boss 117 to rotate thereon. Reduced pressure is adjusted by positioning the internal groove 115 of the rotary member 113 over one, both  
15 or neither of ports of the ported nub 114. The internal groove 115 is open to atmosphere. The ports extend into the interior of the breast shield assembly 16'. Depending upon whether the internal groove 115 is over one port or both ports, suction or reduced pressure is thereby modified by allowing air to bleed into the breast shield assembly 16' through the vacuum regulator 112. The regulator 112 is easily rotated, and conveniently located, allowing the user to manipulate it with one finger, if desired.

20 A valve mechanism 118 is located at the lower portion of catch chamber 119. The valve mechanism 118 is described in U.S. Patent No. 4,929,229, with a flexible disk 125 mounted to cover openings in a valve housing 126 in a flap-valve fashion. When the breast pump is operated, the disk 125 is caused to close underlying apertures in the valve housing 126 under negative pressure, thus closing the collection chamber 119.  
25 When the vacuum is released, milk collected in the collection chamber 119 flows downwardly into the container 38 through the apertures past the disk 125. The valve housing 126 may be attached to the outside of a short tubular extension of the collection chamber 119 via a snug interference fit.

The double-diaphragm pump 110 is adapted to be carried by one of the breast  
30 shield assemblies 16', enhancing its portability. To this end, one or (as shown here)

both of the assemblies 16' has an enlarged collar or skirt 120 formed thereon, which is in communication with the shield 36 via orifice 121. This collar 120 forms a generally hemispherical rigid shell much like that of rigid cap 86 of the embodiment described in regard to FIG. 2, for example, and functioning to the same end. A rigid cap 122 is also provided for the double-diaphragm breast pump 110, which again is similar to that of the rigid cap 86 in function, as discussed hereafter.

As shown in FIG. 12, the double-diaphragm pump 110 has a motor 124, which in this embodiment is a suitable DC gear motor. Motor 124 is fixedly mounted to a pump housing 128. Pump housing 128 is generally cylindrical (tubular), with radially extending disk-shaped mounting flanges just inboard from each end. The motor 124 extends through and is held within a motor mount 131 formed by a hole extending through the side of the housing body 128. A motor cover (not shown) would preferably surround the motor 124.

A drive shaft 44' extends from the motor 124 and is rotated by the motor. Fixed to the drive shaft 44' is an eccentric element 52'. Fixed to and extending from the eccentric 52' is a pin 134, which functions much like the post 58 of the aforescribed embodiment of FIG. 2. That is, as eccentric 52' is rotated by the drive shaft 44', the pin 134 will orbit the drive shaft.

Mounted upon the pin 134 are a pair of pullers 48'. Each puller 48' has a pair of parallel legs 49'. Holes 65a, 65b are provided in each of the legs through which the pin 134 is received. The pin 134 rotates freely within the holes 65a, 65b. It will be noted that the pullers 48' extend in opposite directions, with the legs 49' of the pullers staggered when mounted on the pin 134. A spacer 136 is used between two legs of the respective pullers 48'. A retaining nut 134 is mounted on the free end of the pin 134 to retain the pullers 48' in place.

In this embodiment, a flexible diaphragm 70' is fixed in place, as by insert molding, silicone glue or the like, to an end disk 60' of each puller 48'. One of the diaphragms 70' is received within the hemispherical shell formed by collar 120. This is accomplished using a diaphragm mounting ring 74' having an upstanding collar or shoulder 76'. Lip 80' of the diaphragm 70' (FIG. 12) fits over the outboard side of

the shoulder 76' in an airtight engagement. When this diaphragm 70' is inserted within the collar 120, its flange 80' is pressed between the inboard side of the collar 120 and the outboard side of the shoulder 76', in essence forming a gasket. This seals its engagement with the collar 120, and retains the pump 110 within the breast shield assembly 16'. An identical mounting arrangement is used for the other diaphragm 70' within the rigid cap 122.

Of course, the mounting arrangement for the diaphragm 70' could also be adapted in a manner as shown in FIG. 8. The diaphragm could also be glued to the ring 74'.

In operation of the embodiment of FIGS. 11 and 12, one of the diaphragms 70' of the double-diaphragm pump 110 is mounted within the collar 120 of a breast shield assembly 16'. A rigid cap 122 is placed over the other diaphragm 70'. When the motor 124 is actuated, each of the diaphragms 70' is caused to reciprocate, thereby generating an intermittent vacuum (negative pressure) in its respective breast shield 36. This vacuum will obviously alternate between the breasts. Reciprocation is accomplished through the action of the pin 134 as it revolves with the eccentric 52', pulling one puller 48' and pushing the other.

With respect to the vacuum being generated within the rigid cap 122, it is communicated to the remote breast shield assembly 16' via tubing 18. One end of the tubing 18 is connected to a spigot 138 formed with the cap 122, and a spigot-like adapter 139 inserted into the other tube end and into an aperture formed in the collar 120. Of course, if only one breast is to be pumped at a time, the tubing 18 need not be connected, and the cap 122 can simply be vented to atmosphere.

Yet another double-diaphragm embodiment is shown in FIGS. 13 through 17. This takes the form of a table-top version, generally indicated at 150. In this embodiment the double-diaphragm pump is located within a two-piece rigid housing having housing halves 151a and 151b. Formed integral with each housing half is a diaphragm mounting ring 74'' (FIG. 14) with upstanding collar or shoulder 76''. Received thereon is a respective diaphragm 70''. The diaphragms 70'' can most preferably be integrally molded with the housing halves. A hemispherical rigid cap

122' is provided for each housing half, and serves to form an airtight engagement with the diaphragm 70'' in the same manner as described with respect to the other double-diaphragm embodiment. A spigot 138 extends from each of the caps 122', and is connected to a respective breast pump assembly 16' via tubing 18 in the manner previously described. It will be noted that the collar 120' shown in this embodiment is not exactly the same as collar 120, in that it is not specifically adapted to receive a diaphragm of the type described with regard to FIGS. 11 and 12, although it could be made so, if desired. Herein, collar 120' is meant to represent that on a conventional breast pump assembly that could receive a manually driven piston pump, such as shown in U.S. Patent 4,929,229.

Referring again to FIGS. 14 and 15, this table-top double-diaphragm pump utilizes pullers 48'' having a single leg 49''. A single hole 65 is provided in the inboard side of each leg 49'', within which pin 134 is rotatably received. Pin 134 is fixed to an eccentric 52'', which in turn is fixedly mounted to a drive shaft 44'' rotated by motor 28''. In this embodiment, motor 28'' is again a DC gear motor. Motor 28'' is capable of being driven by a standard rechargeable battery (not shown), such as a NiCd or NiMH camcorder-type battery, which would be mounted in place on the housing in standard well known fashion, as at battery mounting sidewall 152. An alternative DC adapter for use with an AC power source can be provided (not shown), which would be electrically connected at port 154, again using standard circuitry and adapter technology which is well known.

Each puller 48'' has an end disk 60'' which is fixed to a diaphragm 70'', as by welding, gluing or the like. The pullers 48'' are reciprocated in the same manner as previously described under action of the pin 134 orbiting on the eccentric 52''. Vacuum is alternately generated in the respective breast shield assemblies 16' in this manner.

In this table-top embodiment 150, the caps 122' are each provided with a vacuum regulation device. This takes the form of a flexible ring 160 which is mounted in a channel 161 (FIG. 16) formed in a collar portion 164 that extends outwardly from the cap 122'. Flexible ring 160 overlies a vent hole 165 which

communicates with the space between the interior of the cap 122' and the diaphragm 70''. The flexible ring 160 forms an air seal with the channel 161, except for a portion 166 comprising a small channel 166 in the ring 160. This small channel 166 is rotatable to positions where it will connect one, both or none of apertures 167a, 167b formed in the radially extending outboard lip 164a of the collar portion 164. This respectively will correspond to a previously determined medium (one aperture), minimum (both) or maximum (neither) vacuum pressure. This pressure regulation is advantageously independently provided for each breast shield in this manner.

Motor 28'' is actuated by on-off rocker switch 170. It is contemplated, however, that the motor drive could be modified to include an adjustable speed regulation, such as through use of a circuit having an adjustable diode arrangement for current control to the motor.

The embodiment of FIGS. 13 through 18 also provides a sound-deadening and vibration-reducing feature. This is provided by soft material such as Santoprene supplied by Advanced Elastomer Systems, of Akron, Ohio. This is a thermoplastic elastomer which is insert-molded into each housing half 151a, 151b. As shown here, this material is formed in a pyramidal pattern 175 on the broadest part of interior sidewalls of each half 151a, 151b, and in an elongated peak-and-valley pattern 176 along the remainder of each half. Other patterns could be used.

Feet 176 (FIG. 17) are also molded on the housing valves 151a, 151b using the same thermoplastic elastomer.

Most desirably, the sound/vibration reducing material, feet 176 and diaphragms 70'', are all insert-molded at the same time with the housing valves. This greatly reduces and simplifies assembly.

FIGS. 19 and 20 show designs which would be variants on the type of diaphragm pump shown in the embodiment of FIGS. 11 and 12. These variants would be single pump versions, i.e., not specifically adapted for double-pumping. The FIG. 19 embodiment, for instance, would have a housing 180 for the elements described with the FIG. 11 and 12 version, except only a single diaphragm pump would be provided. An on-off switch is shown at 181, and mounting collar at 120'.

The FIG. 20 embodiment would likewise include the elements of the FIG. 19 embodiment, but is shown in an alternative mounting arrangement, with the diaphragm pump mounting collar 120'' extending from the top of the breast shield assembly.

5           In still another variation on a pump for double breast pumping, the embodiment of FIG. 21 is particularly adapted for pumping both breasts simultaneously, i.e., negative pressure is transmitted to both breasts at the same time. In this proposed version, the motor 28''' has an output shaft 44''' on which an eccentric or cam 52''' is mounted for rotation as in previous described embodiments.  
10       A puller 48''' is likewise similarly mounted to the eccentric 52'''. A guide 40'' is again used to facilitate movement of the diaphragms 70''', two of which are employed. Guide 40'' has a channel 45'' into which the motor shaft 44''' is received. An end of the guide 40'' is fixed to a yoke 190. An end of puller 48''' is likewise fixed to the yoke 190 with a swivel joint connection 191.

15           The two diaphragms 70''' pass through a sheet metal frame 192. The yoke 190 has openings 193 which receive and hold end elements 194 of the diaphragms 70'''. The diaphragms 70''' are themselves mounted within orifice 194 formed in a mounting plate 195. Overlying each of the diaphragms 70''' and fixed, as by screws (not shown), to the mounting plate 195 are plates 24' having rigid caps 86' from  
20       which extend spigots 20'. Diaphragms 70''' operate in conjunction with the caps 86' in the manner previously described. The entire pumping mechanism can be mounted within a bag 14', again as in a manner previously described (i.e., FIG. 1).

          In operation of the FIG. 21 embodiment, rotation of eccentric 52''' causes the puller 48''' to orbit the drive shaft 44'''. This action in turn causes the yoke 190 to  
25       move toward and then away from the frame 192, to thereby reciprocate the diaphragms 70''', simultaneously generating a negative pressure in the respective expandible chamber formed by a diaphragm 70''' and its rigid cap 86'. That negative pressure is communicated through a spigot 20' to a breast shield assembly via tubing, as previously described.

While the invention has been described with respect to a number of embodiments, those with skill in the art will recognize other materials, arrangements, modifications and the like which can be advantageously utilized, yet which will still fall within the scope of the inventive concept, and the claims set forth hereinafter.

**WHAT IS CLAIMED IS:**

1. A pump comprising:

a flexible diaphragm,

a rigid member,

an air seal formed between said diaphragm and said rigid member,

5 a puller member attached to said flexible diaphragm,

a drive member connected to said puller member which drive member is adapted to draw said puller member along with said diaphragm away from said rigid member, thereby creating a space between said diaphragm and said rigid member and forming a pressure region within said space,

10 a motor drive mechanism including said drive member to reciprocate said puller member to first draw said puller member away from said rigid member and then move said puller member back toward said rigid member,

15 an outlet in communication with said space between said diaphragm and said rigid member, and

a vacuum regulator device on said rigid member for adjusting the level of negative pressure within said pressure region when said diaphragm is moved away from said rigid member.

2. The pump of claim 1 wherein said vacuum regulator device comprises a rotary valve member mounted for rotational movement on said rigid member, an aperture being formed through said valve member, and at least one hole formed through said rigid member in communication with said pressure region, said valve member having a first position wherein said valve aperture and said rigid member hole are aligned to place said pressure region in communication with atmosphere, and  
5 a covered position wherein said valve aperture and said rigid member hole are unaligned with said valve member closing said rigid member hole.



3. The pump of claim 2 including a second hole formed through said rigid member, said valve member having a second position wherein said valve aperture and said rigid member second hole are aligned to place said pressure region in communication with atmosphere through said second hole, and wherein said pump has a maximum negative pressure generated in said pressure region when neither said first and second holes are aligned with said valve aperture, a minimum negative pressure generated in said pressure region when said second hole is aligned with said valve aperture, and a negative pressure generated in said pressure region intermediate to that of said maximum and said minimum when said first hole is aligned with said valve aperture.

4. The pump of claim 2 including a second hole formed through said rigid member, said valve member having a second position, said valve member having a channel formed therein overlying said rigid member with said valve member aperture extending into said channel, and wherein said pump has a maximum negative pressure generated in said pressure region when neither said first and second holes are aligned with said channel, a minimum negative pressure generated in said pressure region when said first hole is aligned with said channel, and an intermediate negative pressure to that of said maximum and minimum is generated when said first and second holes are aligned with said channel.

5. A pump comprising:  
a flexible diaphragm,  
a rigid member,  
an air seal formed between said diaphragm and said rigid member,  
a puller member attached to one of said flexible diaphragm and said rigid member,  
a drive member connected to said puller member which drive member is adapted to draw said puller member along with one of said diaphragm and said rigid member from the other of said diaphragm and rigid member thereby creating a space between said diaphragm

and said rigid member and forming a pressure region within said space,

a motor drive mechanism including said drive member to reciprocate said puller member,

15 an outlet in communication with said space between said diaphragm and said rigid member, and

a vacuum regulator device on said rigid member for adjusting the level of negative pressure within said pressure region when said diaphragm is moved away from said rigid member.

6. A pump comprising:

a first member,

a second member movable relative to said first member,

an air seal formed between said first and second members,

5 a puller member attached to said first member,

a drive member connected to said puller member which drive member is adapted to draw said puller member along with said first member away from said second member, thereby creating a space between said first and second members and forming a pressure region within said space,

10 a motor drive mechanism including said drive member to reciprocate said puller member to first draw said puller member away from said second member and then move said puller member back toward said second member,

15 an outlet in communication with said space between said first and second members, and

a vacuum regulator device on one of said first and second members for adjusting the level of negative pressure within said pressure region.

7. A vacuum regulator device for a breastpump comprising:

a base in communication with a volume which is subject to a source of vacuum;

a rotary disk member mounted upon said base;

5       said base having at least one hole formed therein which extends into said volume;

      said rotary disk member overlying said base and having an aperture therethrough which is alignable with said at least one hole.

8. A breastpump comprising:

      first and second motor driven pumps each generating a negative pressure, with an outlet on each pump communicating with said negative pressure;

5       first and second breast shield assemblies including tubing for connection to a respective pump; and

      a vacuum regulator associated with a respective pump, whereby the negative pressure generated by each said pump is independently regulatable.

9. The breastpump of claim 8 wherein each said motor driven pump includes a rigid shell, a flexible diaphragm sealingly mounted to said shell for movement relative to said shell, with a respective vacuum regulator being mounted on said rigid shell.

10. A pump for use with a breast shield assembly in the expression of mother's milk, comprising:

      a flexible diaphragm,

      a stationary cap member surrounding said flexible diaphragm,

5       an air seal formed between said diaphragm and said cap member,

      a puller attached to said flexible diaphragm,

      a follower connected to said puller member which follower is adapted to draw said puller member along with said diaphragm away from said cap member, thereby creating a space between said diaphragm and

10                   said rigid member and forming a negative pressure region within  
                    said space,  
                    a motor drive mechanism including a cam member mounted to turn with a  
                    drive shaft with said follower mounted off-center on said cam  
                    member and off-axis to said drive shaft, said cam member when  
15                   rotated by said drive shaft causing said follower to reciprocate said  
                    puller member to first draw said puller member away from said cap  
                    member and then move said puller member back toward said cap  
                    member, and  
                    an outlet in communication with said space between said diaphragm and  
20                   said cap member which outlet is used to convey a pressure  
                    generated in said space, such as said negative pressure, to a breast  
                    shield assembly for use in extracting mother's milk.

                    11. The pump of claim 10 further including a pair of outlets in communication  
                    with said space between said diaphragm and said rigid member, each of said outlets  
                    being connectable to a respective breast shield assembly, and a closure member for  
                    closing one of said outlets when said pump is used with a single breast shield  
5                   assembly, said closure member including a relief port for allowing a predetermined  
                    amount of air to flow into said pressure region when a negative pressure is generated  
                    within said pressure region to generally yield the same negative pressure at a single  
                    breast shield assembly as when using two breast shield assemblies without said  
                    closure.

                    12. A pump comprising:  
                    a flexible diaphragm having a front side and a back side,  
                    a stationary cap member surrounding said flexible diaphragm front side,  
                    an air seal formed between said diaphragm and said cap member,  
5                   a puller attached to said flexible diaphragm,  
                    a follower pivotably connected to said puller member which follower is  
                    adapted to draw said puller member along with said diaphragm

away from said cap member, thereby creating a space between said diaphragm and said rigid member and forming a negative pressure region within said space,

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a motor drive mechanism including a cam member mounted to rotate with a drive shaft with said follower movably mounted off-center on said cam member and off-axis to said drive shaft, said cam member when rotated by said drive shaft causing said follower to reciprocate said puller member to first draw said puller member away from said cap member and then move said puller member back toward said cap member,

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a puller guide having a channel formed therein, and a guide member which extends into said guide channel for constrained relative movement within said channel as said puller member reciprocates, said puller, puller guide and guide member cooperating together to maintain said puller moving along an axis generally perpendicular to said diaphragm, and

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an outlet in communication with said space between said diaphragm and said cap member which outlet is used to convey a pressure generated in said space to a workpiece.

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13. The pump of claim 12 wherein a follower is pivotably connected to said puller member which follower is adapted to draw said puller member along with said diaphragm away from said cap member, said motor drive mechanism including a cam member mounted to rotate with a drive shaft with said follower movably mounted off-center on said cam member and off-axis to said drive shaft, said cam member when rotated by said drive shaft causing said follower to reciprocate said puller member to first draw said puller member away from said cap member and then move said puller member back toward said cap member, and a stationary guide having a channel formed therein, and a guide member mounted on said puller member which guide member extends into said guide for constrained movement within said channel as said puller member reciprocates.

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14. The breastpump of claim 13 further comprising:

a vacuum regulator communicating with said space between said diaphragm and said cap member.

15. The breastpump of claim 14 wherein said vacuum regulator comprises a disk which is rotatably mounted on said cap member, said disk having an aperture formed therethrough which is selectively alignable with at least one opening through said cap member and extending into said space between said diaphragm and cap member.

16. The breastpump of claim 14 wherein said vacuum regulator device comprises a rotary valve member mounted for rotational movement on said cap member, an aperture being formed through said valve member, and at least one hole formed through said rigid member in communication with said pressure region, said valve member having a first position wherein said valve aperture and said rigid member hole are aligned to place said pressure region in communication with atmosphere, and a covered position wherein said valve aperture and said rigid member hole are unaligned with said valve member closing said rigid member hole.

17. The breastpump of claim 16 including a second hole formed through said rigid member, said valve member having a second position wherein said valve aperture and said rigid member second hole are aligned to place said pressure region in communication with atmosphere through said second hole, and wherein said pump has a maximum negative pressure generated in said pressure region when neither said first and second holes are aligned with said valve aperture, a minimum negative pressure generated in said pressure region when said second hole is aligned with said valve aperture, and a negative pressure generated in said pressure region intermediate to that of said maximum and said minimum when said first hole is aligned with said valve aperture.

18. A pump mechanism for a breastpump comprising:

a motor drive having a drive shaft output;  
an eccentric mounted to be rotated by said drive shaft output;  
a first and a second puller;

5 a first and a second expansible chamber, each said expansible chamber  
having a flexible diaphragm which is movable relative to a base  
member and is generally air sealed with respect to said base member  
so as to form a variable volume with said base member by  
movement of said diaphragm, each said diaphragm having a front  
10 side and a back side;

an outlet in communication with a variable volume of a respective chamber;  
said first puller being connected to said first expansible chamber to move  
its flexible diaphragm relative to a respective base member, and said  
second puller being connected to said second expansible chamber to  
15 move its flexible diaphragm relative to a respective base member,  
said first and second pullers being connected to be moved by said  
eccentric in a push-pull arrangement, whereby as said eccentric is  
rotated one expansible chamber has a decreasing volume and the  
other expansible chamber has an increasing volume.

19. The pump mechanism of claim 18 wherein said first puller is connected to  
said flexible diaphragm of said first expansible chamber, said second puller is  
connected to said flexible diaphragm of said second expansible chamber, each said  
puller being pivotably mounted to said eccentric and extending in generally opposite  
5 directions from said eccentric with said expansible chambers on generally opposite  
sides of said eccentric, with said eccentric being mounted to said drive shaft.

20. The pump mechanism of claim 19 wherein each said base member is a  
rigid cap within which a respective diaphragm is received to move relative to a cap  
interior wall, said rigid cap for said first expansible chamber being formed integral  
with a breast shield assembly and the other rigid cap for said second expansible  
5 chamber being mounted to a pump mechanism housing, with said outlet of said

second expansible chamber communicating with a second breast shield assembly via tubing.

21. The pump mechanism of claim 19 wherein each said base member is a rigid cap within which a respective diaphragm is received to move relative to a cap interior wall, each said rigid cap being formed in a pump mechanism housing, with said outlets of said first and second expansible chambers communicating with a  
5        respective breast shield assembly via tubing.

22. A pump mechanism for a breastpump comprising:

a motor drive,

a first and a second puller;

a mechanism connecting said first and second puller to said motor drive;

5        a first and a second expansible chamber, each said expansible chamber having a first member which is movable relative to a base member and is generally air sealed with respect to said base member so as to form a variable volume with said base member by movement of said first member,

10       a first outlet in communication with the variable volume of said first chamber and a second outlet in communication with the variable volume of said second chamber;

15       said first puller being connected to said first expansible chamber to move its first member relative to a respective base member, and said second puller being connected to said second expansible chamber to move its first member relative to a respective base member, said first and second pullers being connected to be moved in a push-pull arrangement by said by said mechanism, whereby as said motor is operated one expansible chamber has a decreasing volume and the  
20       other expansible chamber has an increasing volume.

23. A pump mechanism for a breastpump comprising:



a motor drive;

a first and a second expansible chamber, each said expansible chamber having an element which is movable relative to a base member with said element and base member being generally air sealed with respect to each other so as to form a variable volume between them by movement of said element relative to said base member, with an outlet in communication with a respective variable volume; and

a drive train being connected to said motor drive and to said first and second expansible chambers to move each expansible chamber element relative to a respective base member.

24. The pump mechanism of claim 23 wherein said element is a flexible diaphragm and said base member is a rigid member to which said diaphragm is mounted and having a respective outlet formed in said rigid member, said diaphragm being moved in relation to said rigid member by a drive train including an eccentric which is rotated by said motor drive, with a first puller mounted to move with said eccentric and connected to the diaphragm of said first expansible chamber, and a second puller mounted to move with said eccentric and connected to the diaphragm of said second expansible chamber, said first and second pullers extending in generally opposite directions from said eccentric so as to expand the volume of one expansible chamber while contracting the volume of the other expansible chamber as said eccentric rotates.

25. The pump mechanism of claim 23 wherein said element is a flexible diaphragm and said base member is a rigid member to which said diaphragm is mounted and having a respective outlet formed in said rigid member, said diaphragm being moved in relation to said rigid member by a drive train including an eccentric which is rotated by said motor drive, with a puller mounted to move with said eccentric and connected to a yoke, the diaphragms of said first and second expansible chambers being connected to said yoke so as to expand and contract the volumes of said expansible chambers in tandem as said eccentric is rotated.

26. A pump mechanism for a breastpump comprising:

a motor drive;

a first and a second expansible chamber, each said expansible chamber having an element which is movable relative to a base member with said element and base member being generally air sealed with respect to each other so as to form a variable volume between them by movement of said element relative to said base member;

a first outlet in communication with the variable volume of said first chamber and a second outlet in communication with the variable volume of said second chamber;

a drive train connected to said motor drive and to said first and second expansible chambers to move each expansible chamber element relative to a respective base member, and

a housing for said motor drive, expansible chambers and drive train;

said housing, said motor drive, said first and second chambers and said drive chain being arranged in a hand-held unit.

27. The pump mechanism of claim 26 wherein the base member of said first expansible chamber is a rigid cap attached to a first breast shield assembly within which the element of said first expansible chamber is received in sealing engagement, with said pump mechanism thereby being carried by said first breast shield assembly, and the base member of said second expansible chamber is a rigid cap within which the element of said second expansible chamber is received in sealing engagement, and further including tubing connecting the outlet of said second expansible chamber with a second breast shield assembly.

28. The pump mechanism of claim 27 wherein said element is a flexible diaphragm, said diaphragm being moved in relation to said cap member by a drive train including an eccentric which is rotated by said motor drive, with a first puller mounted to move with said eccentric and connected to the diaphragm of said first expansible chamber, and a second puller mounted to move with said eccentric and

connected to the diaphragm of said second expansible chamber, said first and second pullers extending in generally opposite directions from said eccentric so as to expand the volume of one expansible chamber while contracting the volume of the other expansible chamber as said eccentric rotates.

29. A pump mechanism for a breastpump comprising:

a motor drive;

a first and a second expansible chamber, each said expansible chamber having an element which is movable relative to a base member with said element and base member being generally air sealed with respect to each other so as to form a variable volume between them by movement of said element relative to said base member;

an outlet for each variable volume of a respective chamber;

a drive train connected to said motor drive and to said first and second expansible chambers to move each expansible chamber element relative to a respective base member, and

a housing having each said base member integrally formed therein, said housing further containing said motor drive, expansible chambers and drive train.

30. The breastpump of claim 29 wherein each said base member is a rigid hemispherical cap respectively formed in opposite sidewalls of said housing, the element of a respective first and second expansible chamber being received in sealing engagement with its respective cap, and further including tubing connecting the outlet of each said first and second expansible chamber with a respective breast shield assembly.

31. The breastpump of claim 30 wherein said element is a flexible diaphragm, said diaphragm being moved in relation to said cap by a drive train including an eccentric which is rotated by said motor drive, with a first puller mounted to move with said eccentric and connected to the diaphragm of said first expansible chamber, and a second puller mounted to move with said eccentric and connected to the

diaphragm of said second expansible chamber, said first and second pullers extending in generally opposite directions from said eccentric so as to expand the volume of one expansible chamber while contracting the volume of the other expansible chamber as said eccentric rotates.

32. A housing for a pump mechanism of a breastpump comprising:

first and second housing parts which assemble to provide an interior space  
for containing pump mechanism components; and  
a noise and vibration reducing material formed integral with said housing  
parts adjacent said interior space.

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33. The housing of claim 32 further including a flexible diaphragm formed integral with each housing part.

34. A housing for a pump mechanism of a breastpump comprising:

first and second housing parts which assemble to provide an interior space  
adapted to contain pump mechanism components, and a flexible  
diaphragm formed integral with each housing part.

35. The housing of claim 34 wherein said flexible diaphragm is fixed within an opening defined in a respective housing part, and further including a rigid hemispherical cap member which is removably and sealingly mountable over said opening on the outboard side of each housing part, said cap member and respective diaphragm together forming an expansible chamber for generating air pressure variations therein.

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36. The housing of claim 35 further including a noise and vibration reducing material formed integral with said housing parts adjacent said interior space.

37. A housing for a pump mechanism of a breastpump comprising a flexible diaphragm formed integral with the housing.

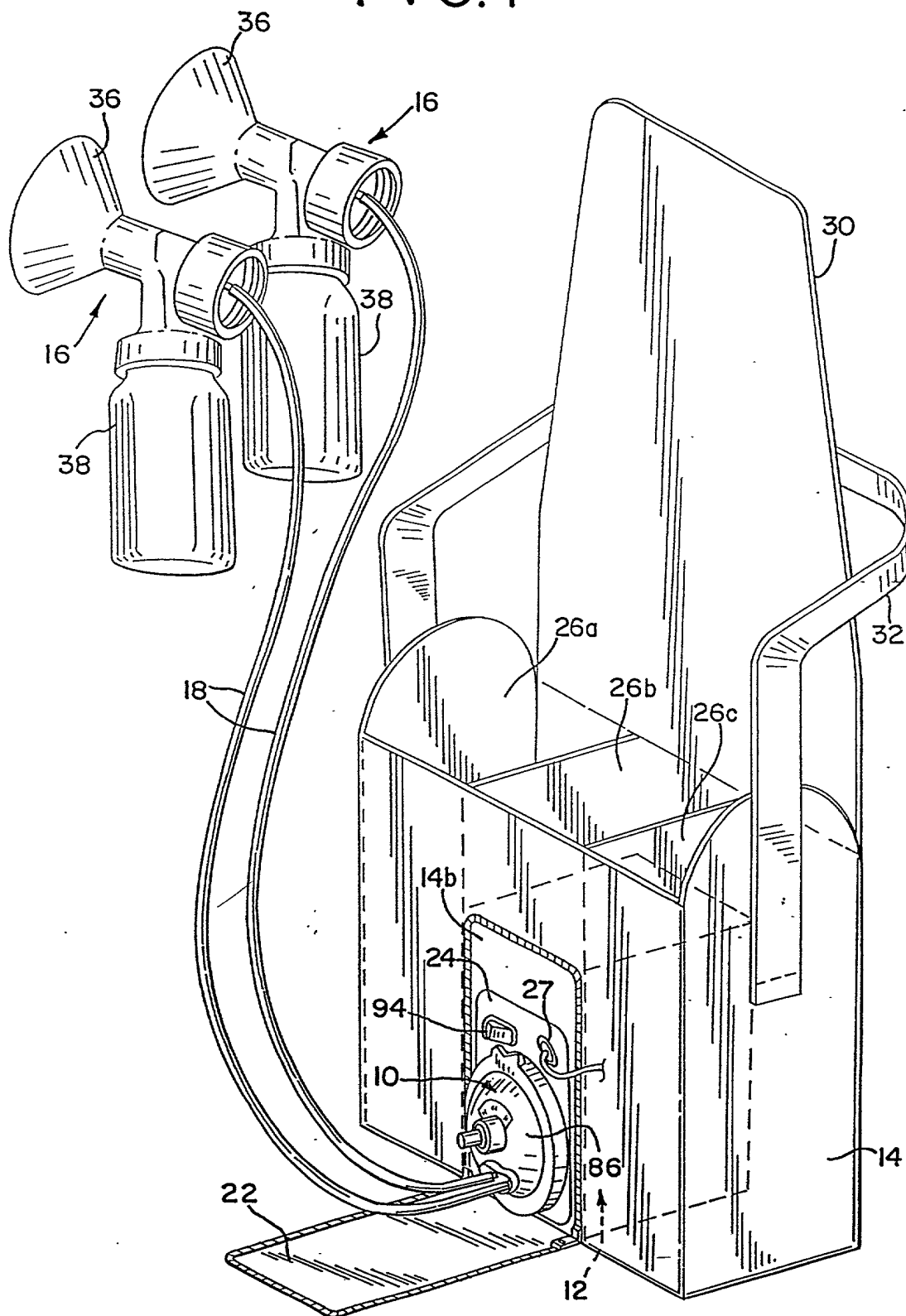
5 38. The housing of claim 37 wherein said flexible diaphragm is fixed within an opening defined in a respective housing part, and further including a rigid hemispherical cap member which is removably and sealingly mountable over said opening on the outboard side of each housing part, said cap member and respective diaphragm together forming an expansible chamber for generating air pressure variations therein.

39. The housing of claim 38 further including a noise and vibration reducing material formed integral with said housing parts adjacent said interior space.

**ABSTRACT**

A motorized pump is disclosed that includes a flexible diaphragm fitting within a rigid member, a motor drive mechanism for drawing a puller member attached to the diaphragm away from the rigid member to create a space between the diaphragm and the rigid member and form a negative pressure region within that space, and an outlet communicating with the negative pressure region. In one embodiment, the pump provides a negative pressure in a single chamber which can be used to operate one or two breast shield assemblies. In another embodiment, the pump is particularly adapted for double-pumping and provides two chambers which generate vacuum.

FIG. 1



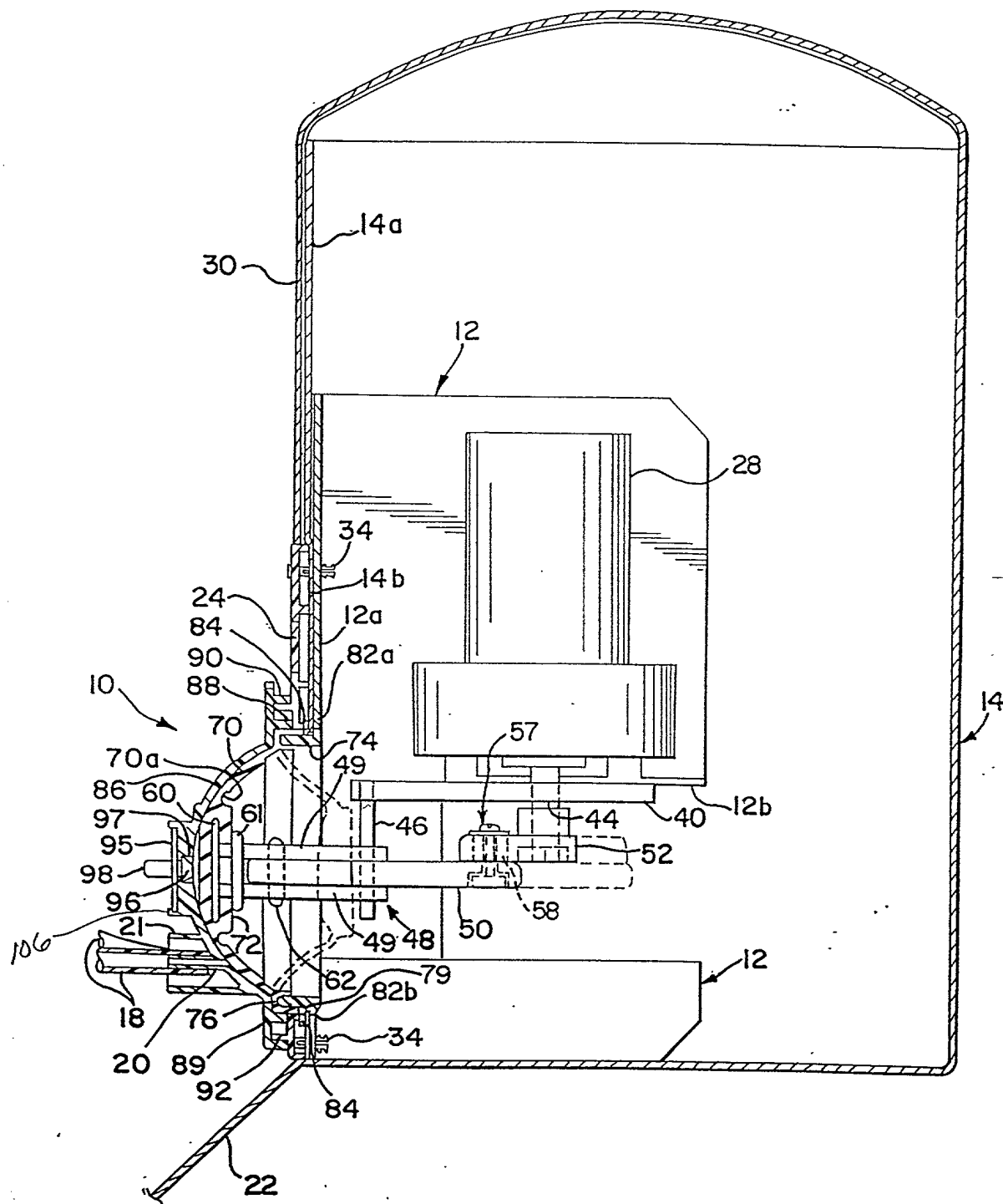




FIG. 3

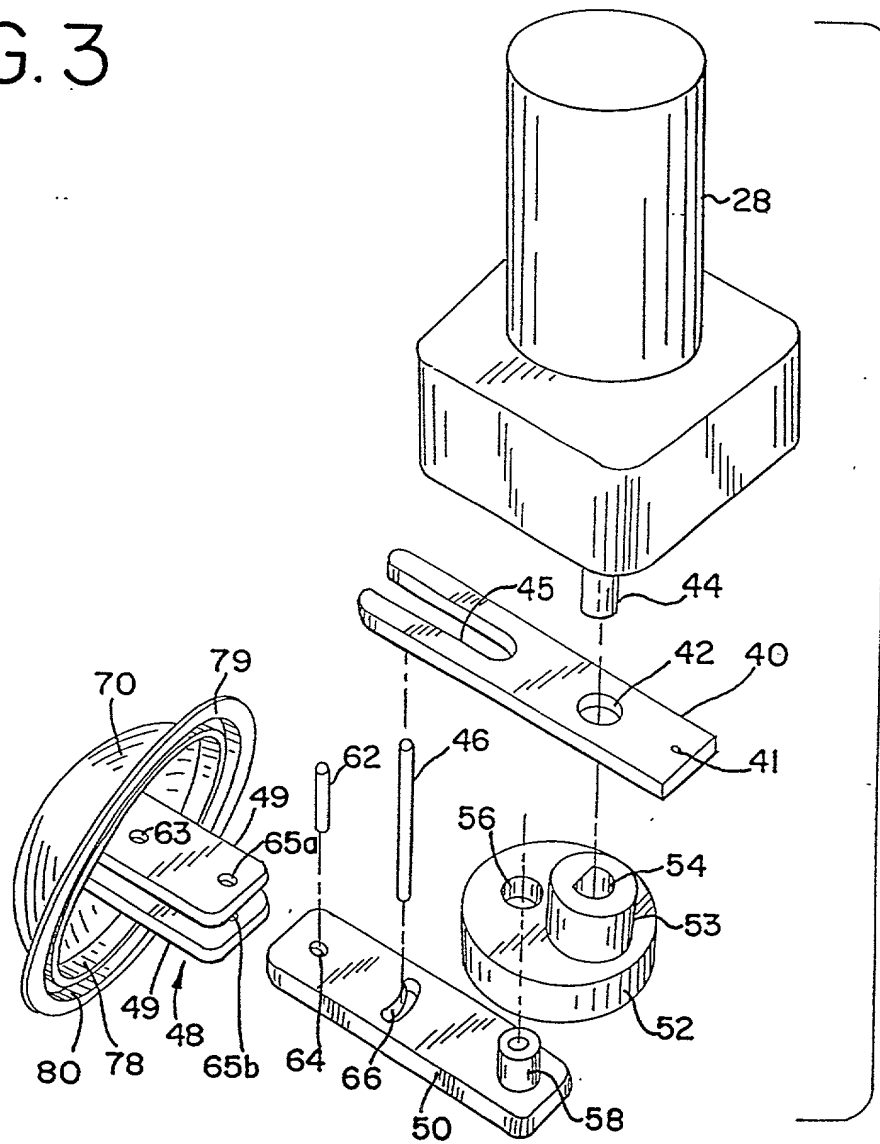


FIG. 5

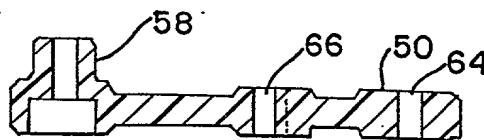


FIG. 4

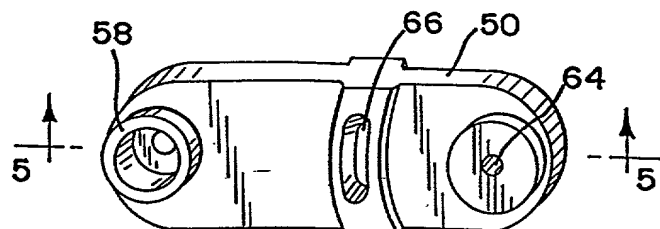


FIG. 6

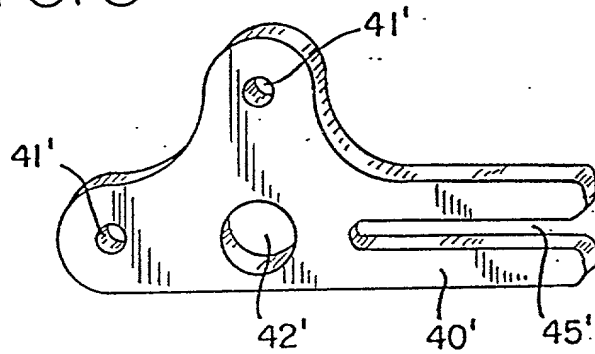


FIG 7A

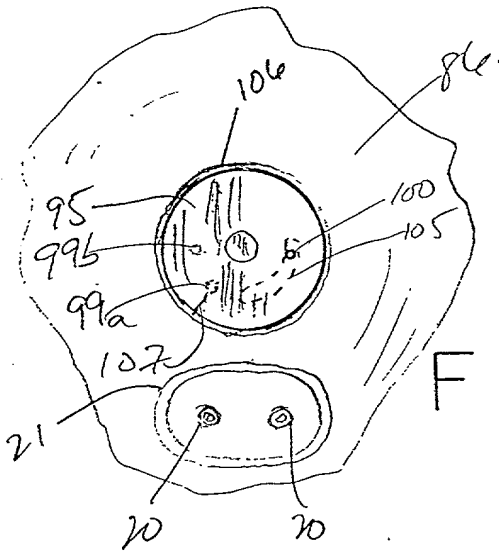


FIG. 7

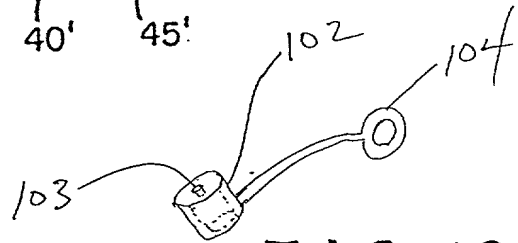
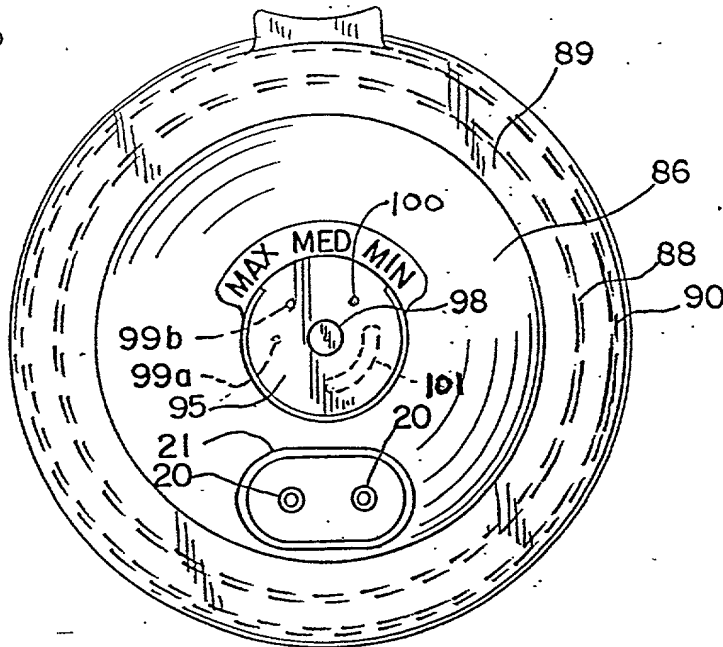


FIG. 10

FIG. 7B

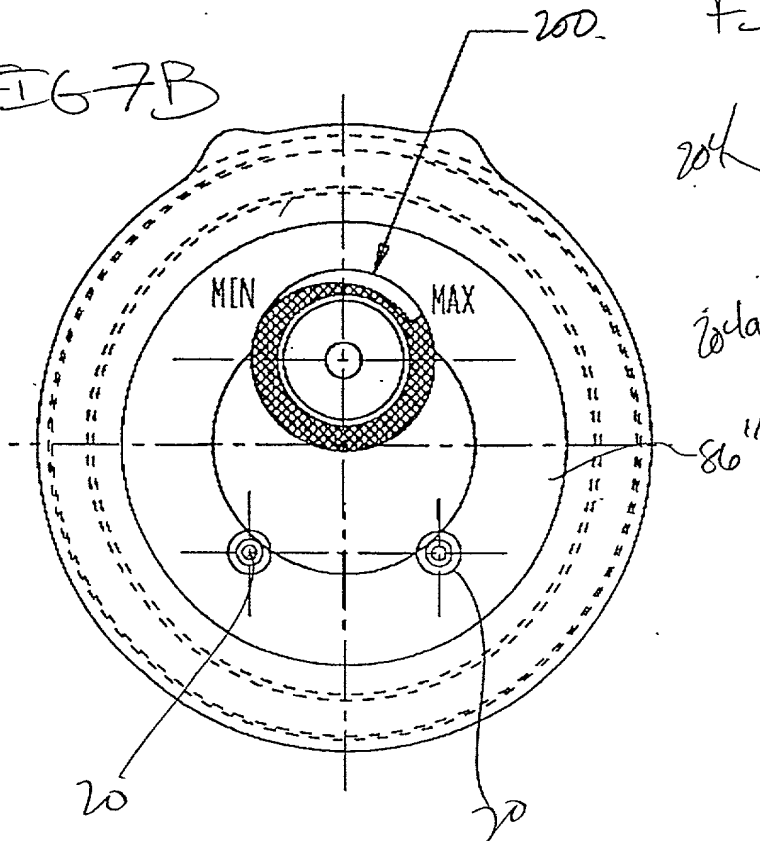


FIG. 7D

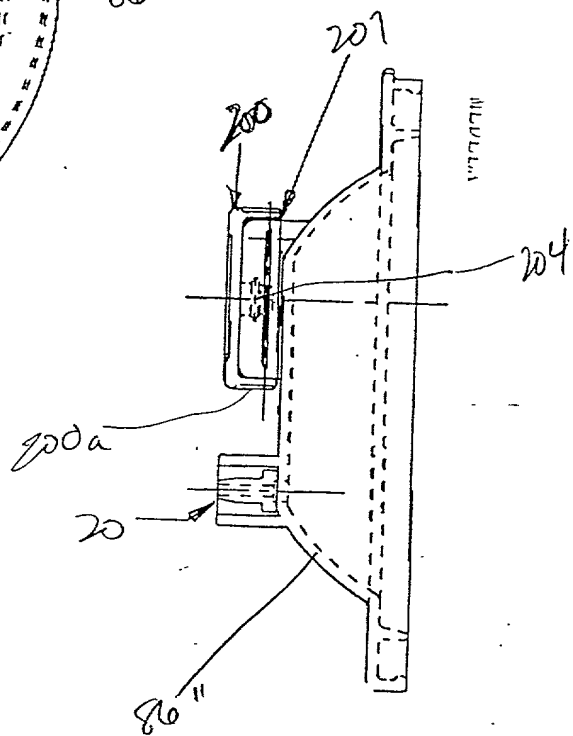
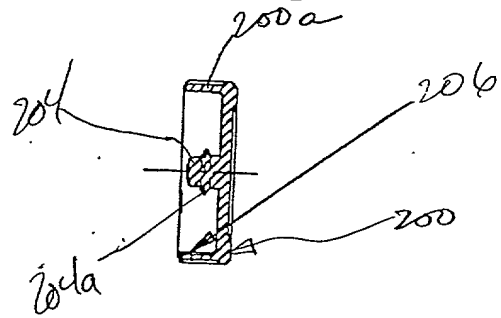


FIG. 7C

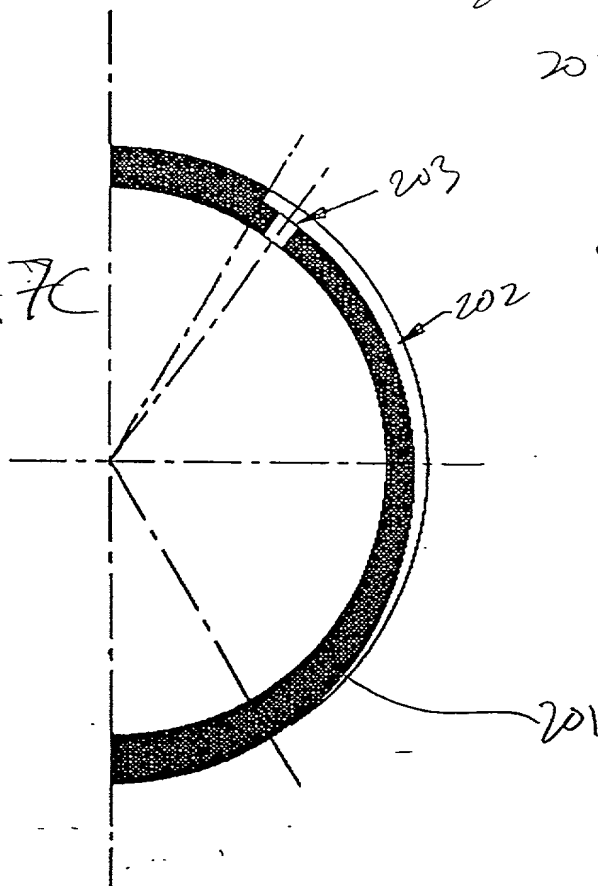


FIG. 8

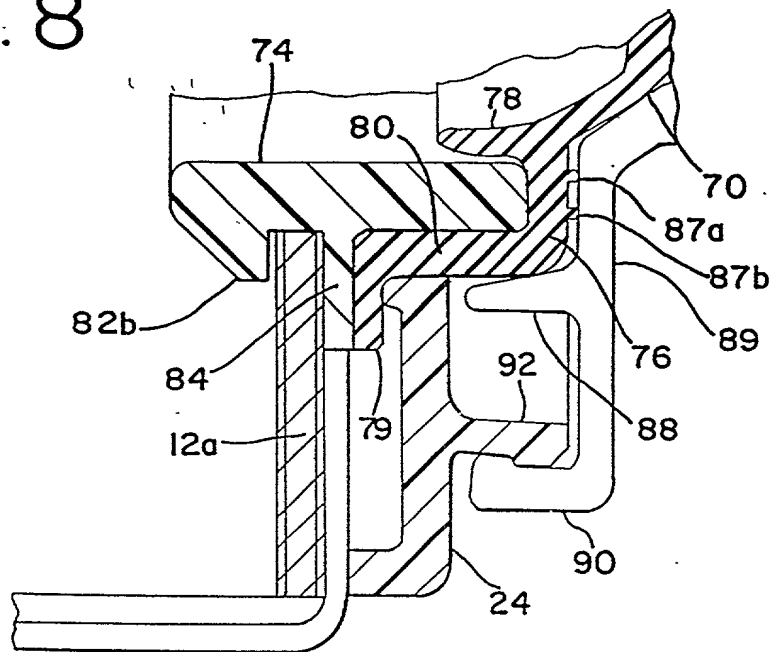


FIG. 9

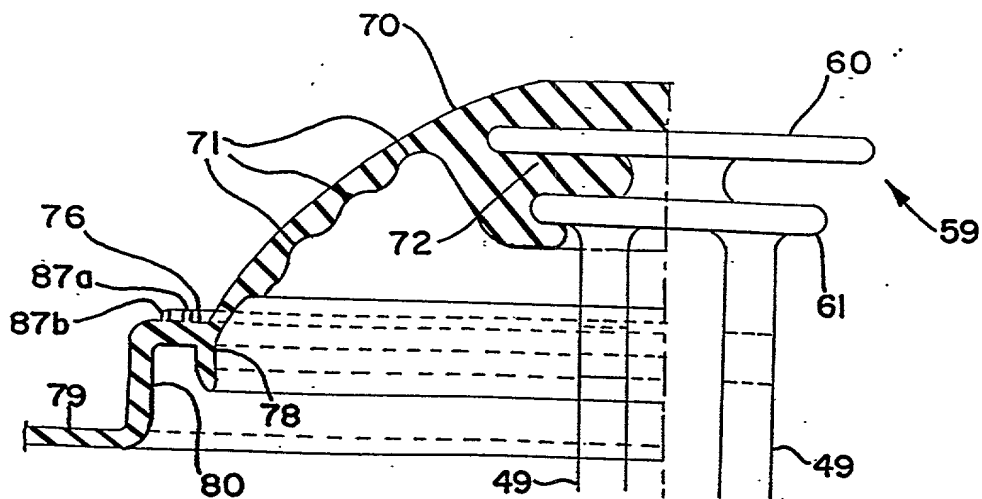
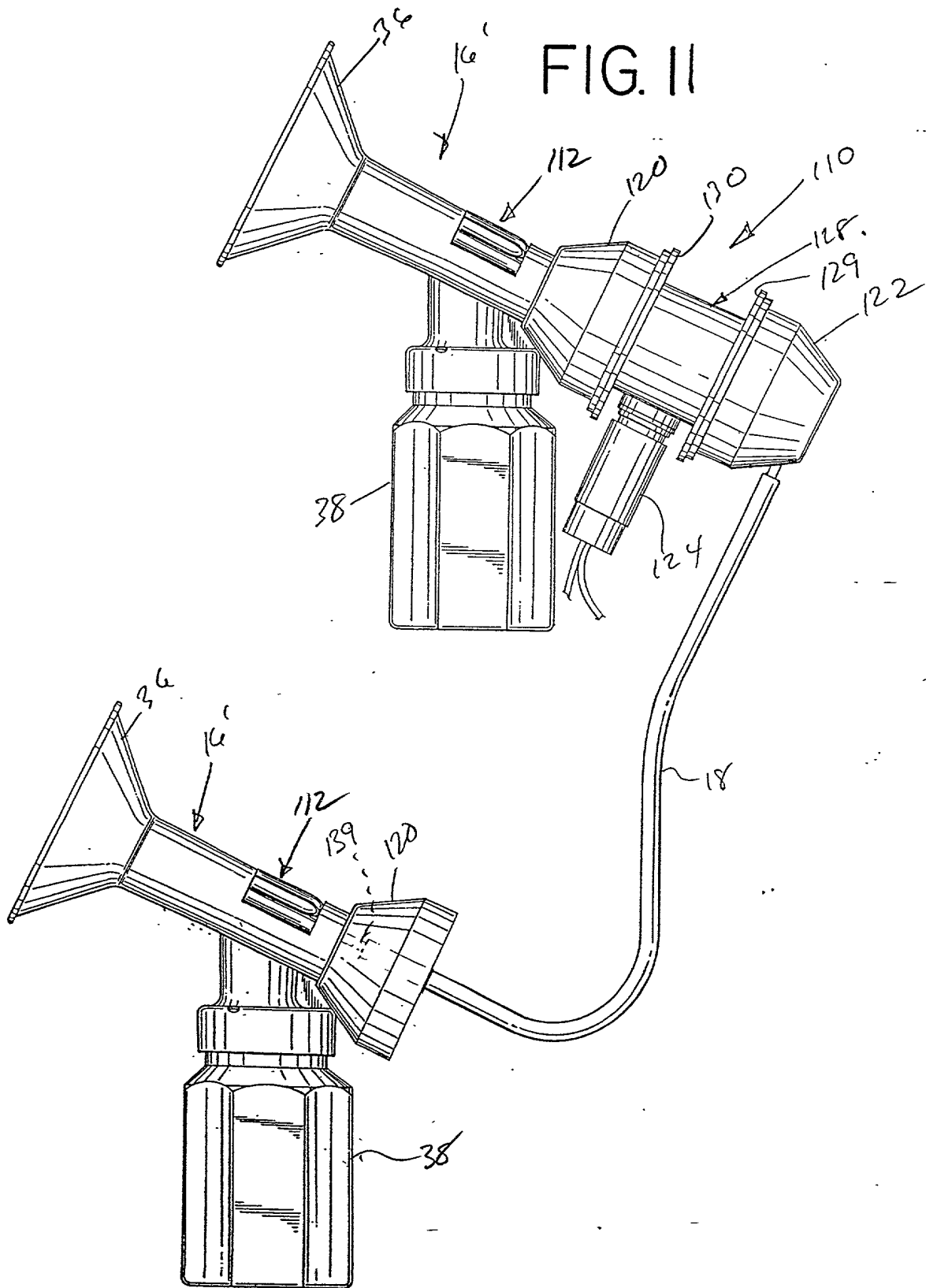


FIG. II



*(The following names are those appearing on the original document.)*

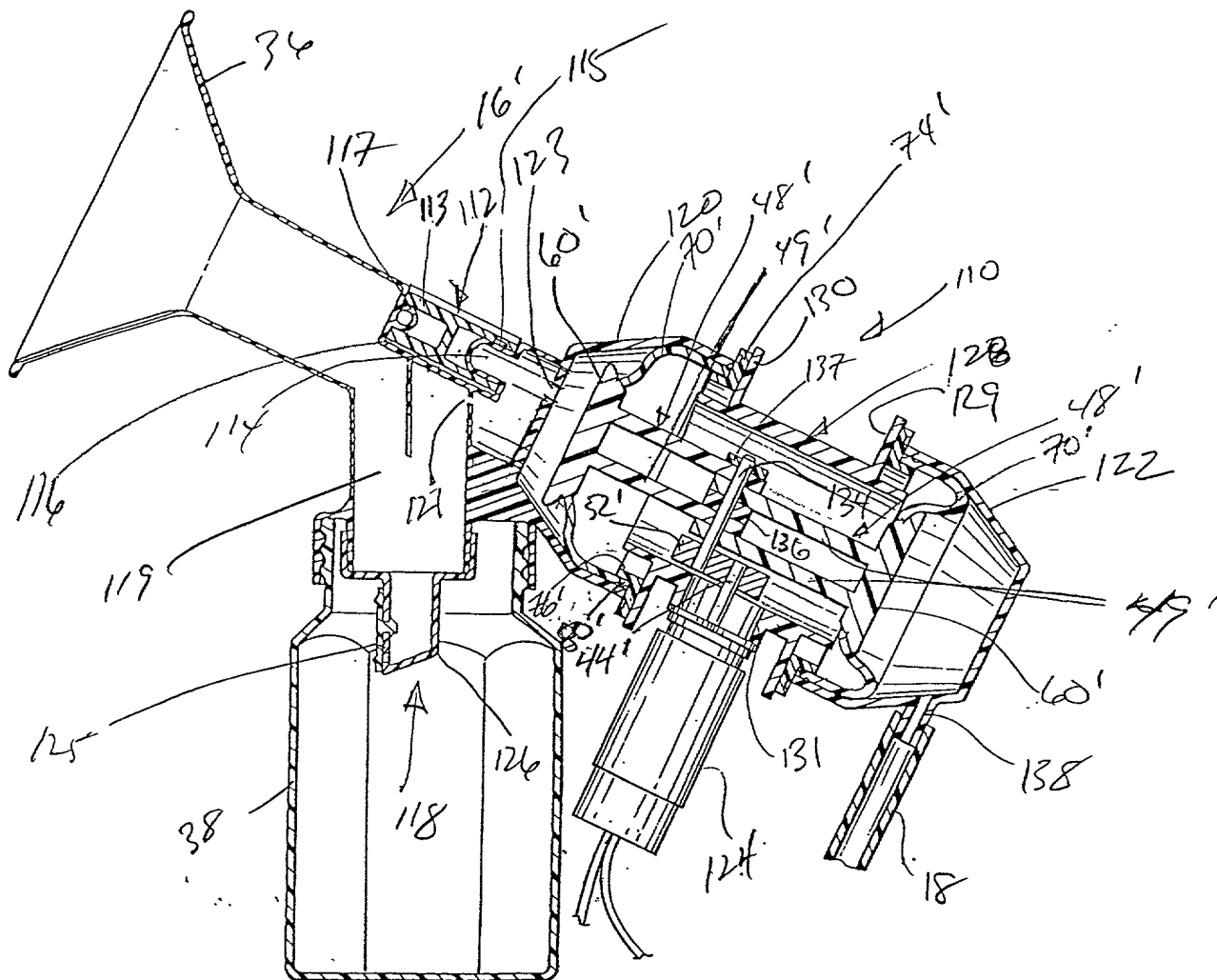
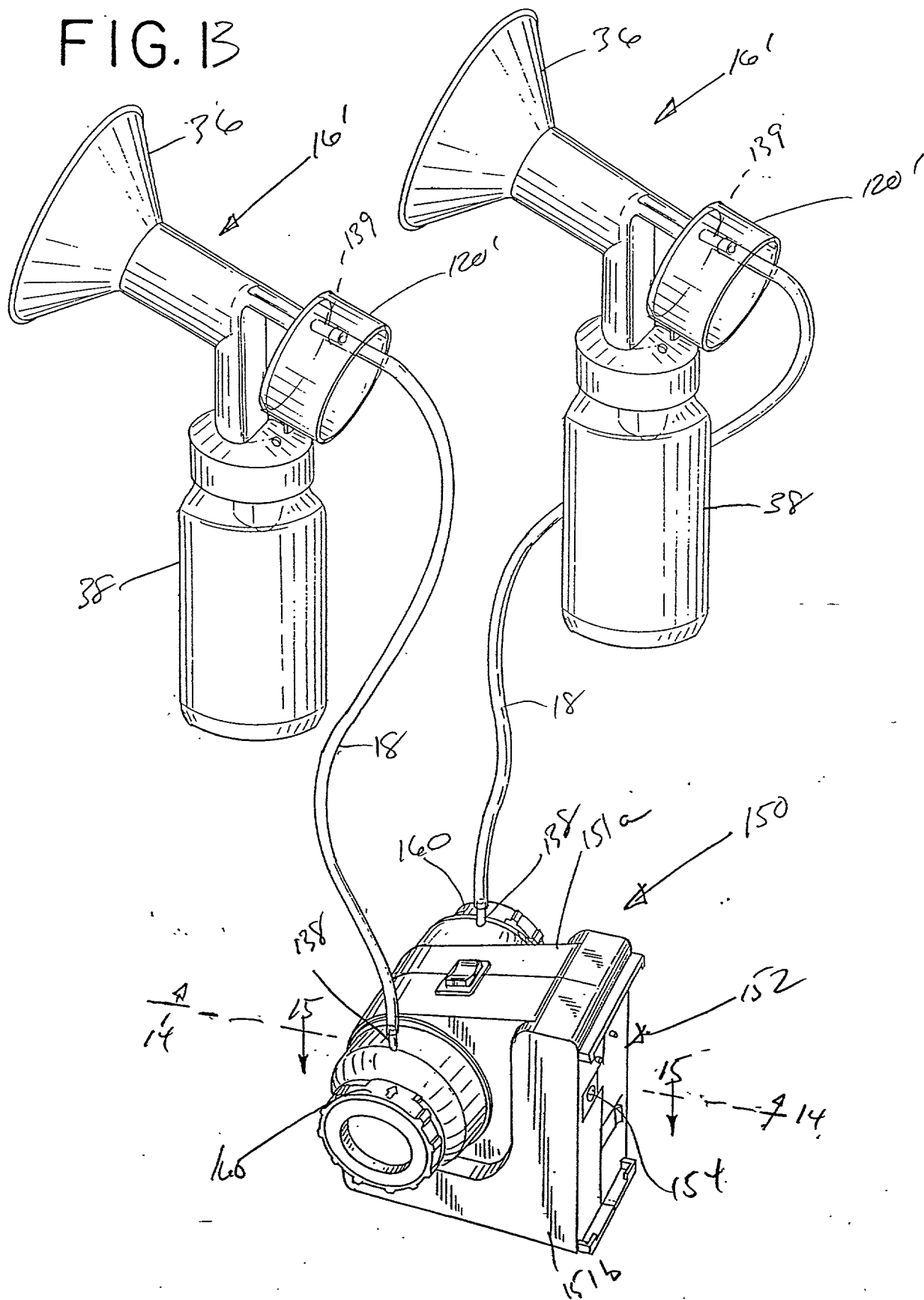


FIG. 13



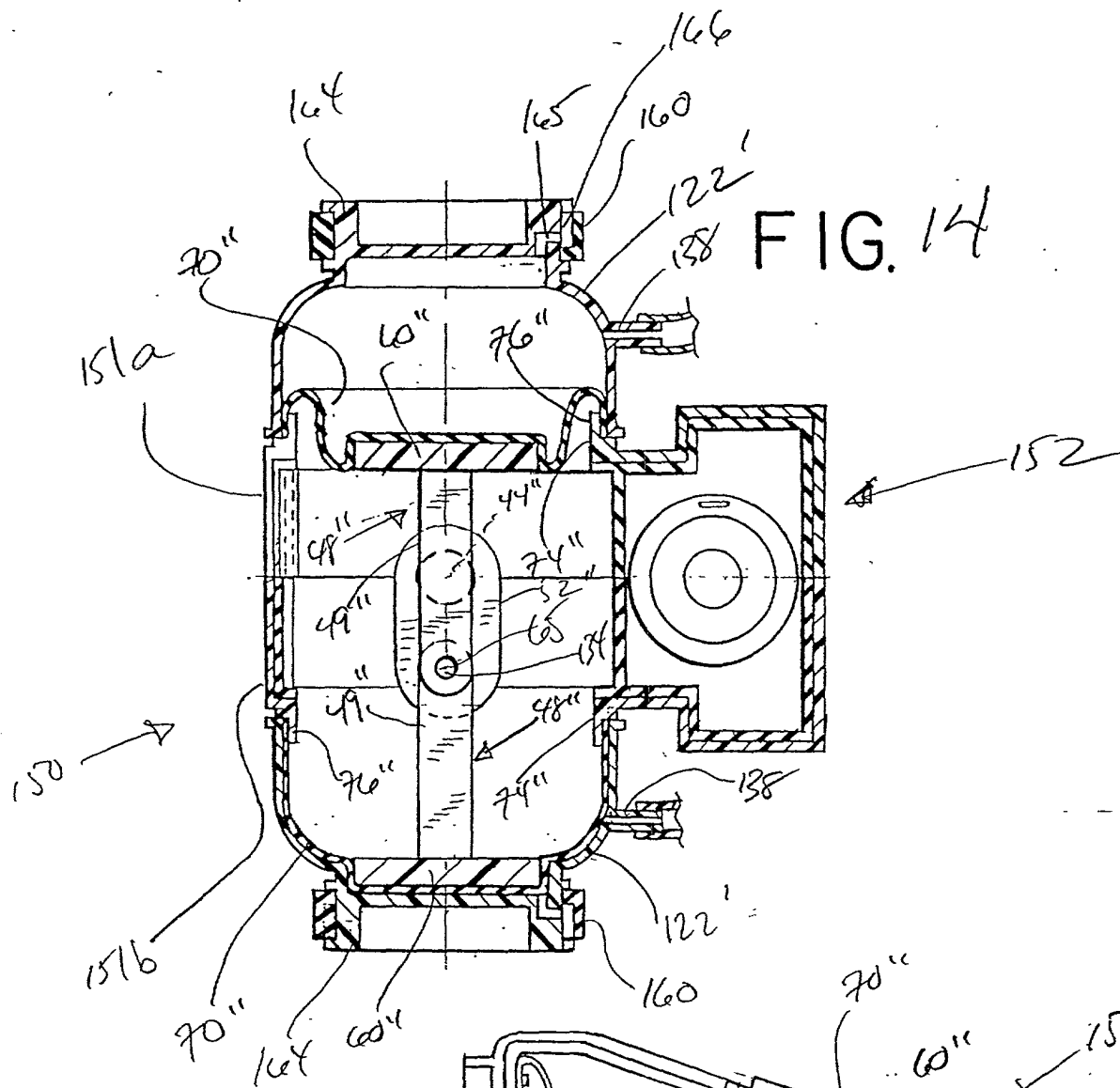
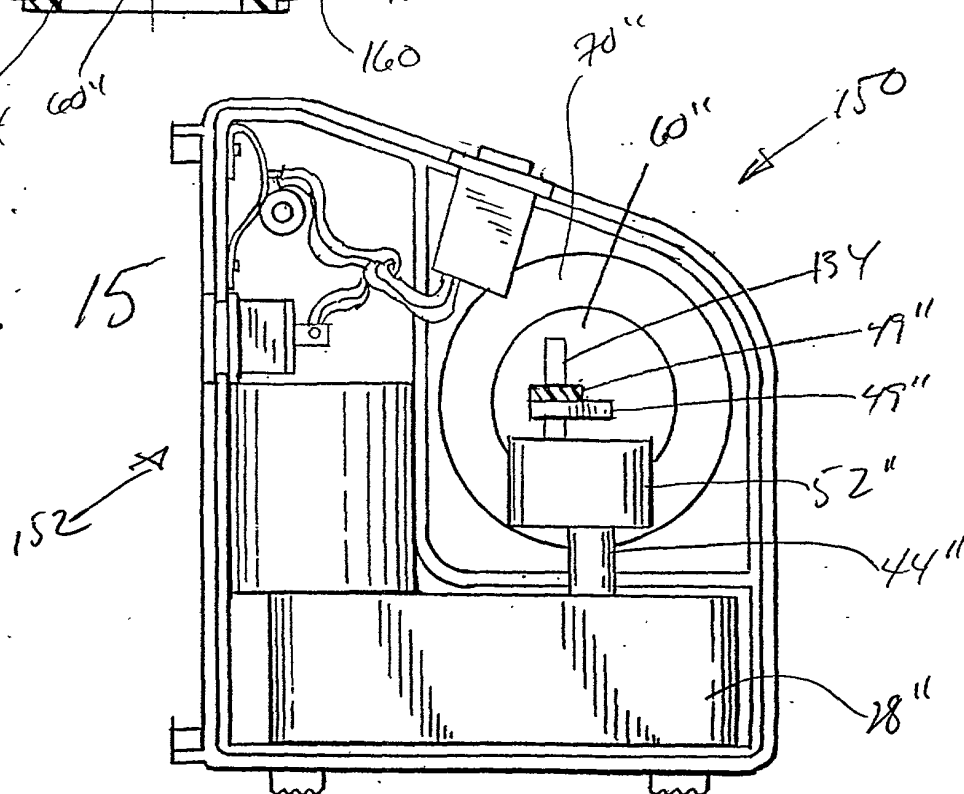
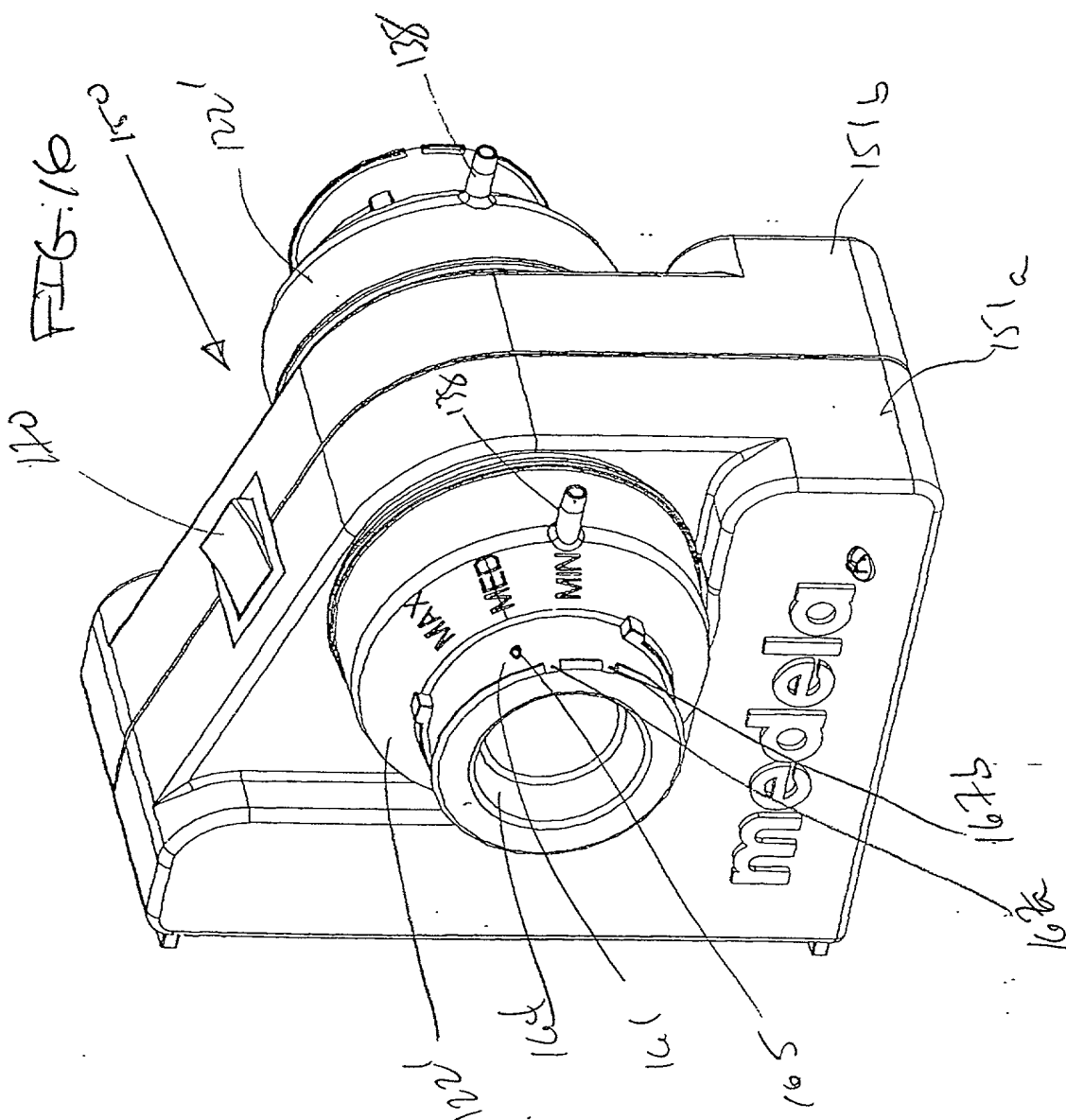


FIG. 15







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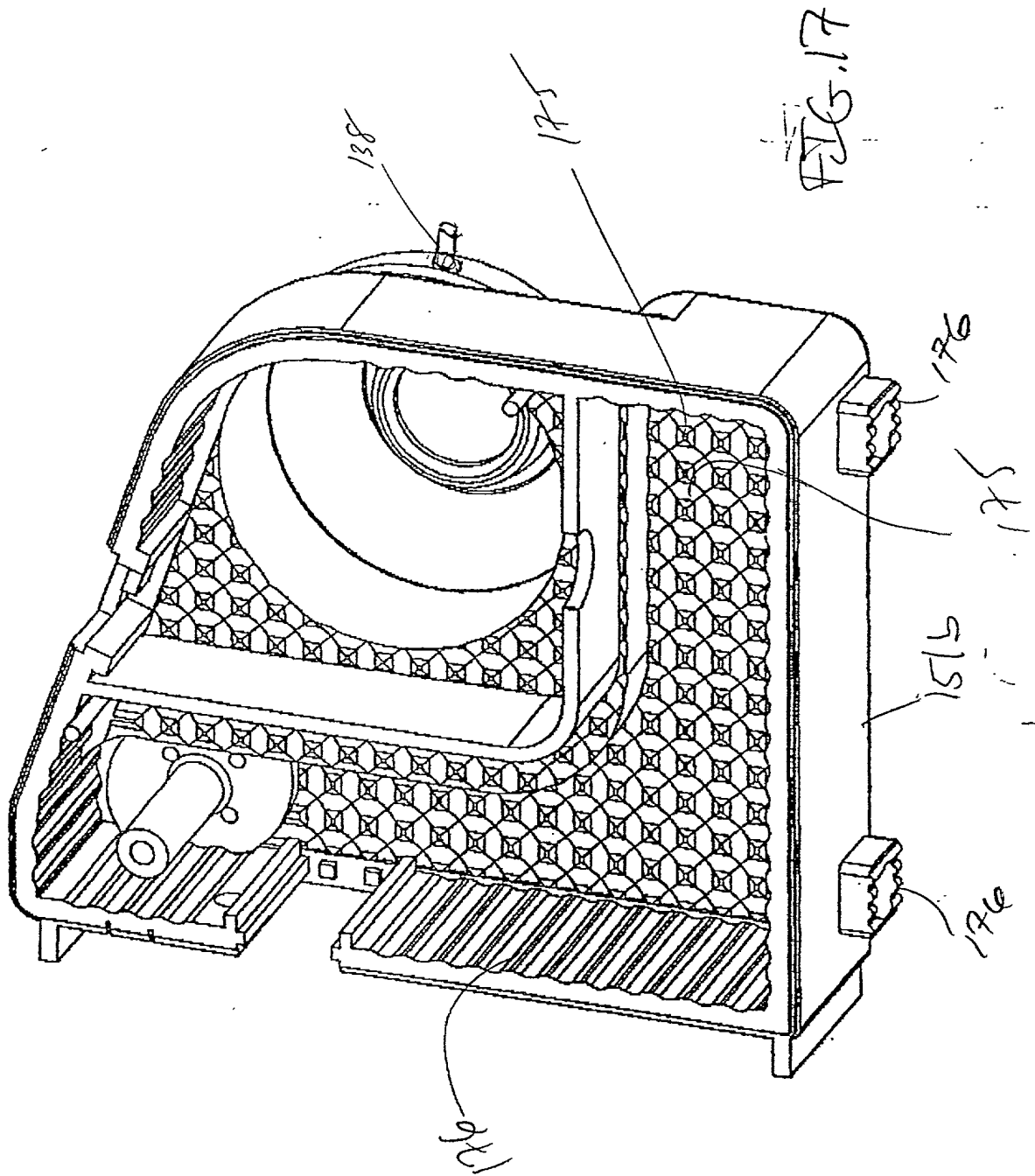
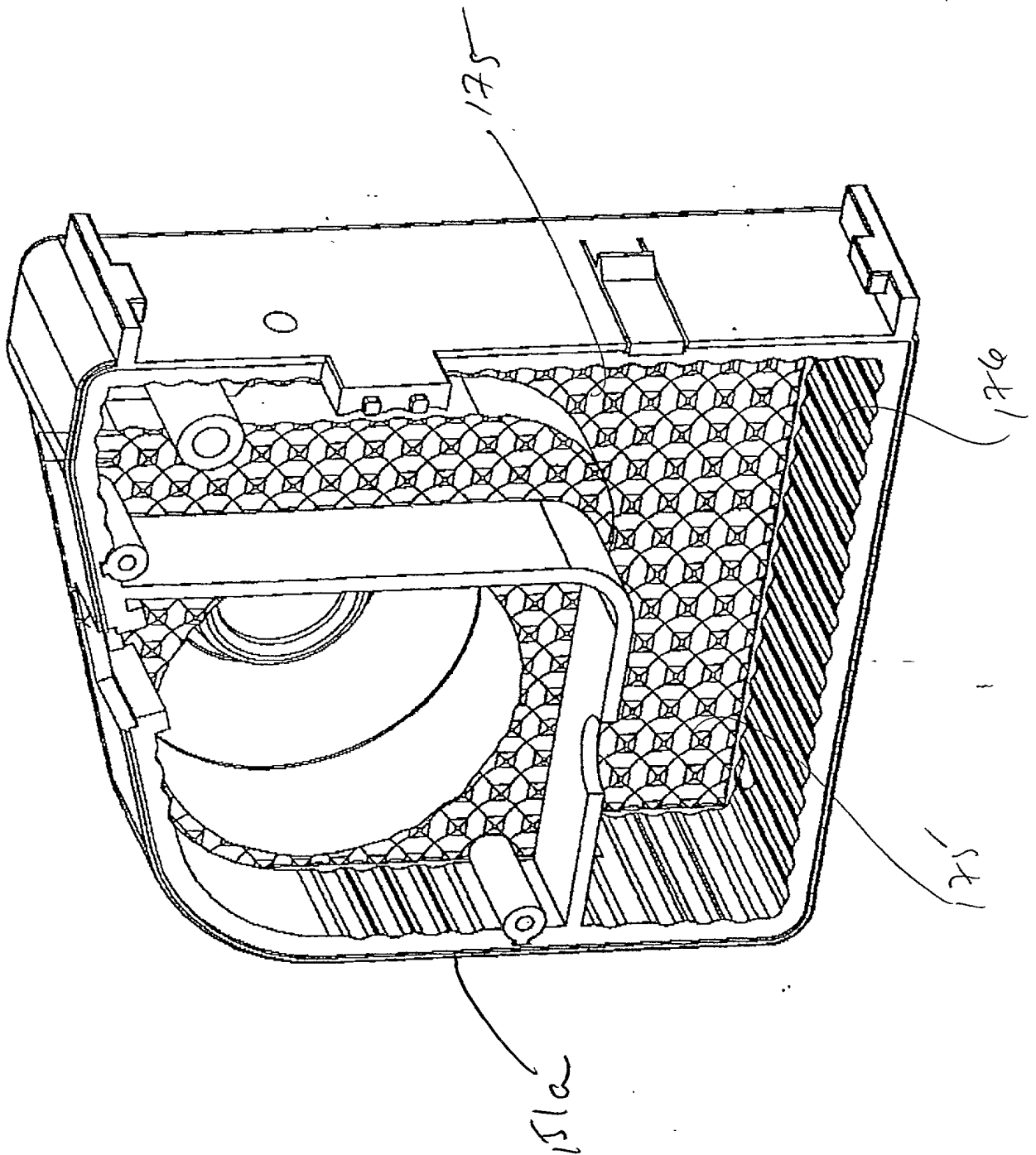
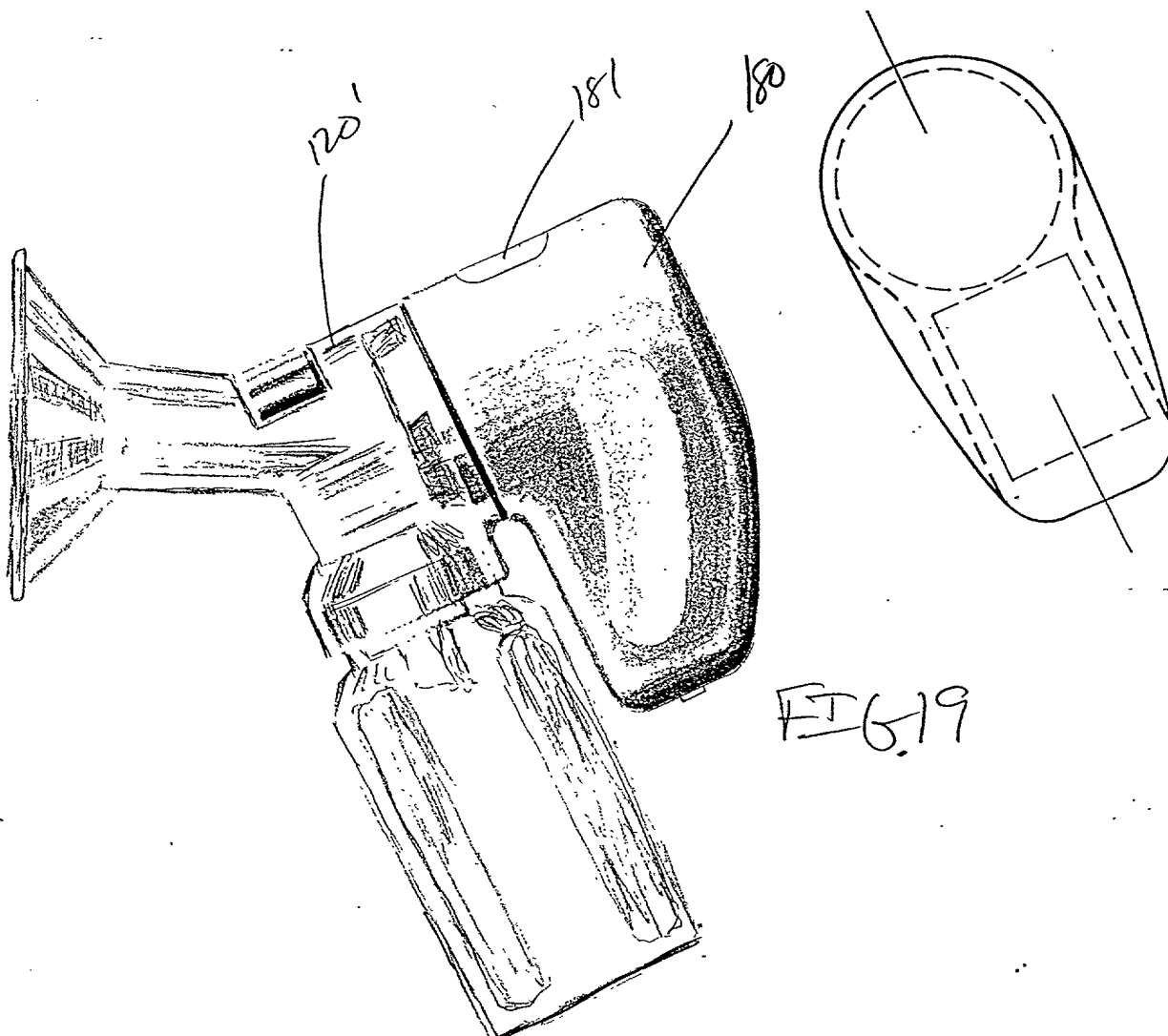


FIG. 18





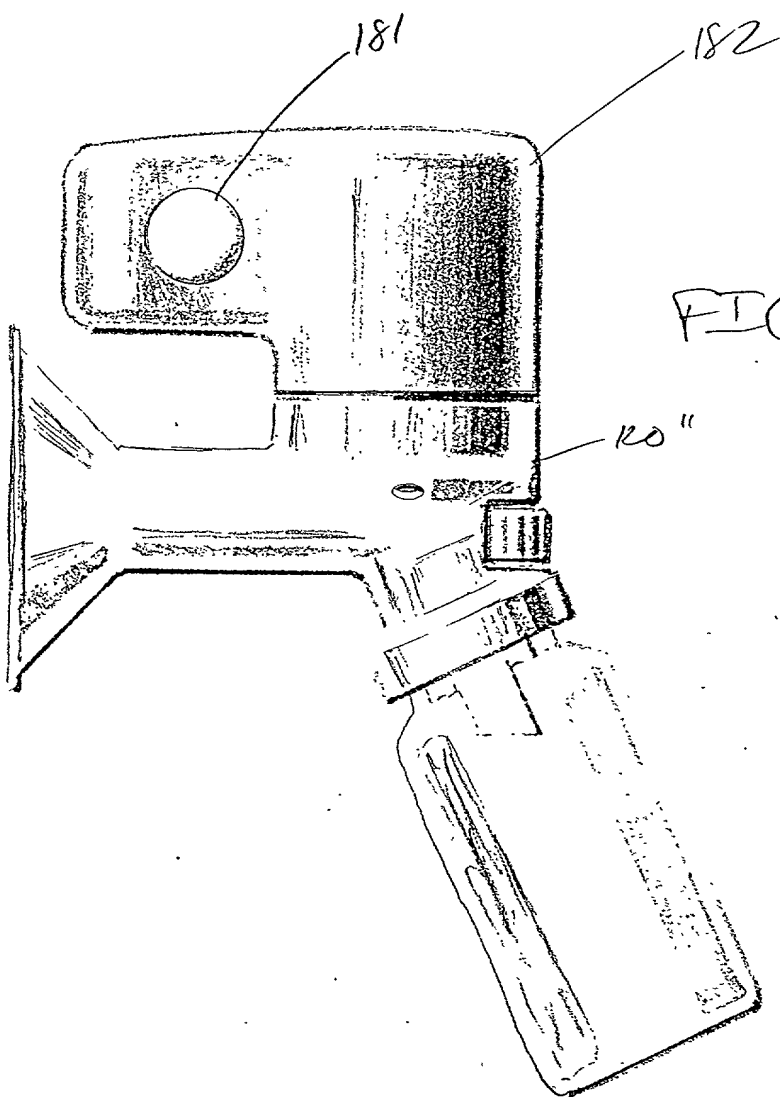
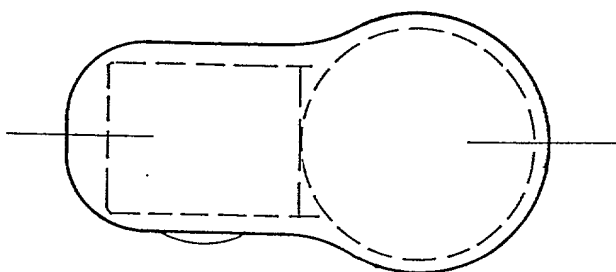
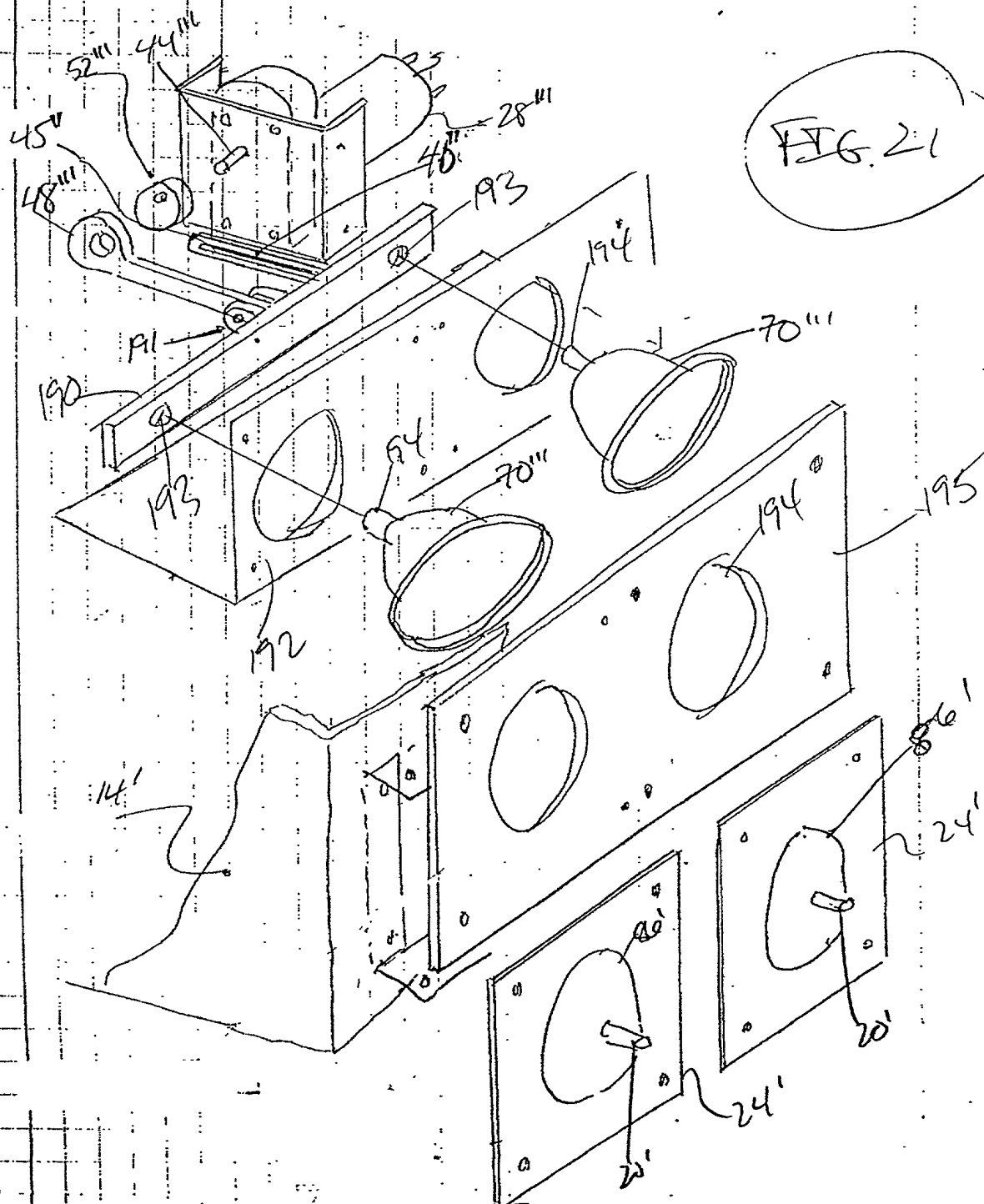


FIG. 20



**DECLARATION FOR PATENT APPLICATION**

Case No. 5297/79

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled DIAPHRAGM PUMP AND PUMP FOR DOUBLE-BREAST PUMPING, the specification of which:

- ☒ is attached hereto.  
☐ was filed on \_\_\_\_\_ as Application Serial No. \_\_\_\_\_.  
☐ and was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability as defined in Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

☐ Yes ☐ No

(Number) (Country) (Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

(Application Serial No.) (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

08/510,714

August 3, 1995

Pending

(Application Serial No.)

(Filing Date)

(Status-patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

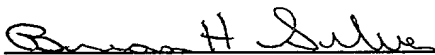
Inventor's Signature

Full name of sole or first inventor

Residence

Citizenship

Post Office Address



Date: 4/2/98

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U.S.A.

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Inventor's Signature

Full name of sole or first inventor

Residence

Citizenship

Post Office Address



Date: 4/2/98

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(312) 321-4200

Inventor(s): Brian H. Silver and Larry D. Annis  
 Title: Diaphragm Pump and Pump for Double-Breast Pumpgin

**POWER OF ATTORNEY**

The specification of the above-identified patent application:

- ☒ is attached hereto  
☐ was filed on \_\_\_\_\_ as application Serial No. \_\_\_\_\_

I hereby revoke all previously granted powers of attorney in the above-identified patent application and appoint the following attorneys to prosecute said patent application and to transact all business in the Patent and Trademark Office connected therewith:

Michael H. Baniak (30,608)

Please address all correspondence and telephone calls to Michael H. Baniak in care of:

Brinks Hofer Gilson & Lione  
 P.O. Box 10395  
 Chicago, IL 60610  
 (312)321-4200

The undersigned hereby authorizes the U.S. attorneys named herein to accept and follow instructions from Brian H. Silver as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the U.S. attorney and the undersigned. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified by the undersigned.

Medela, Inc., a corporation, certifies that it is the assignee of the entire right, title and interest in the patent application identified above by virtue of either:

- ☒ An assignment from the inventor(s) of the patent application identified above, a copy of which is attached hereto.  
 OR  
☐ An assignment from the inventor(s) of the patent application identified above. The assignment was recorded in the Patent and Trademark Office at Reel \_\_\_\_\_, frame \_\_\_\_\_.  
 OR  
☐ A chain of title from the inventor(s), of the patent application identified above, to the current assignee as shown below:

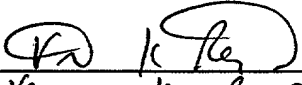
1. From \_\_\_\_\_ To: \_\_\_\_\_  
 The document was recorded in the Patent and Trademark Office at Reel \_\_\_\_\_, frame \_\_\_\_\_, or a copy thereof is attached.
2. From \_\_\_\_\_ To: \_\_\_\_\_  
 The document was recorded in the Patent and Trademark Office at Reel \_\_\_\_\_, frame \_\_\_\_\_, or a copy thereof is attached.

- ☐ Additional documents in the chain of title are listed on a supplemental sheet.

The undersigned has reviewed the assignment or all the documents in the chain of title of the patent application identified above and, to the best of undersigned's knowledge and belief, title is in the assignee identified above.

The undersigned (whose title is supplied below) is empowered to act on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signature:  Date: 4-2-98  
 Name: Vernon K Reizman  
 Title: Controller